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Second Draft

EVALUATING THE PUBLIC HEALTH OF HAZARDOUS WASTE SITE COMMUNITIES:
CURRENT FEDERAL AND STATE POLICIES AND RECOMMENDATIONS
FOR THE MIDWAY LANDFILL COMMUNITY

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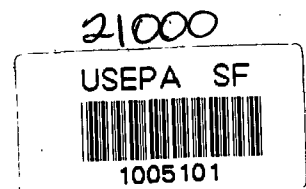


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EVALUATING THE PUBLIC HEALTH OF HAZARDOUS WASTE SITE COMMUNITIES:
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FOR THE MIDWAY LANDFILL COMMUNITY.

I. Introduction

The community surrounding the Midway Landfill in Kent, Washington has voiced concerns regarding the potential public health problems associated with living near the landfill for many years. These concerns include but are not limited to cancer, reproductive dysfunction, birth defects, respiratory disorders, chronic headaches and nosebleeds, learning disabilities, and memory loss. Public health concerns have intensified during the past two years with the inclusion of the Midway Landfill on the Environmental Protection Agency's National Priority List of Hazardous Waste Sites. Although environmental pathways for community exposure to most of the potentially toxic contaminants found in the landfill have not been defined thus far, reports of off-site migration of explosive levels of methane (with low levels of other compounds) and groundwater contaminated with organic solvents and metals have focused the attention of the community on health issues related to toxic exposures. Previous activities of state and local government departments have not provided a satisfactory response to the public health concerns regarding potential toxic exposures and community representatives have demanded that a health survey be performed to document the extent of health problems in the community.

In response to the growing concerns of the Midway community, the author of this report was contracted to review the various policies regarding the investigation of public health problems in hazardous waste site communities. The primary purpose of this review was to evaluate procedures that have been used to study these problems, so as to develop recommendations regarding the appropriate options for the Midway Landfill community. During the development of this report, the author attended numerous local meetings with health department representatives, citizen groups, and individual residents in the community. He has also contacted representatives from the Environmental Protection Agency, the Centers for Disease Control, the Agency for Toxic Substances and Disease Registry, the Citizen's Clearinghouse for Hazardous

Waste and Health Departments from nearly 20 states. In addition, the author has reviewed over 100 published and unpublished reports from scientific journals, public health groups, and state health department files. Finally, the author has attended meetings at the State Health Department in California and the recent American Public Health Association Conference to discuss the broad issues related to this topic with state health officials and public health scientists nationwide.

While many of the issues related to the evaluation of the public health of hazardous waste site communities are local in nature, similar concerns and demands are being raised by communities in many parts of the country. Communities near toxic waste sites are demanding to know the extent of the contamination in their neighborhood and the possible health problems that may result from this contamination. In addition, because of the often sketchy information regarding the extent of the contamination in the environment and the various unexplained health problems of persons in the area, more and more communities are demanding that their local health representatives examine these health problems to evaluate whether they are more common than usual and a result of living near the waste site. In general, state and local health departments do not have the ability to effectively respond to these demands due to restricted resources and insufficient data regarding potential environmental pathways and past and present community exposures. The theme of the recent American Public Health Association (APHA) meetings "Local Health Services: Crisis on the Front Line" accurately describes the current situation in state and local health departments across the country in the area of public health evaluation of hazardous waste site communities. The topic of an entire session at the APHA meeting concerned the role of the community in the evaluation of health and environmental risk. Speakers included representatives from the California Health Department, the Environmental Defense Fund, The University of Michigan, and the Citizen's Clearinghouse for Hazardous Wastes. While the speakers emphasized different methods for the appropriate evaluation of the public health consequences of hazardous waste sites (e.g., vital statistics records, registries, health questionnaires, DNA Adducts, etc.), there was near unanimity regarding the importance of early and continuous community participation in these processes.

The recommendations that are included in this report were developed as a result of the author's evaluation of the current procedures that are available for examining the health problems in the Midway Landfill community. The author has attempted to recommend only those procedures that were considered most appropriate for studying the public health problems in the area. More importantly, these recommendations will establish a process whereby the officials who are responsible for protecting public health, work cooperatively with residents who share their concern, to establish and implement a health evaluation and education program for the community. The ultimate purpose of this program is the collection of information that will provide a comprehensive evaluation of the environmental and health problems in the community.

II. Background

A. Scope of the National Toxic Waste Problem

The purpose of this section is to provide a perspective on the extent of the toxic waste problem in this country. The major points include:

- Currently there are over 700 hazardous waste sites on the EPA's National Priority List for cleanup.
- Estimates of the number of hazardous waste sites that will require cleanup range from 2,000 (according to the EPA) to over 10,000 (according to the Office of Technology Assessment).
- Estimates of the cost and time required to clean up 10,000 hazardous waste sites approach \$100 billion and 50 years
- A substantial proportion of the US population (nearly 50%) live in areas (e.g. counties) that will be affected by toxic waste sites.

In 1980, the United States Congress established the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (1). This act created what is commonly known as the Superfund Program under the direction of the Environmental Protection Agency (EPA). The Superfund Program, financed by a \$1.6 billion trust fund from taxes on chemical and petroleum industries, was established to identify and clean up abandoned or uncontrolled hazardous waste sites (2). The Superfund Program was not established following long and careful deliberation regarding the nation's

hazardous waste problem but was developed quickly to address immediate problems at the worst hazardous waste sites and to respond to imminent threats to human health (3). The EPA devised a Hazardous Ranking System (HRS) for evaluating different sites on the basis of their potential risks to the environment and public (4). The EPA was directed to establish an initial list of at least 400 hazardous waste sites that required cleanup. This list, known as the National Priority List (NPL), contained the 400 waste sites that had received the worst (HRS) numerical scores (at least 28.5). Using the same (HRS) criterion, the (NPL) now contains over 700 sites with at least one site in nearly every state in the country (5). States such as New Jersey, New York, and Michigan lead the list with over 50 sites. The state of Washington currently has 19 sites on the (NPL). A list of the current (NPL) sites for each state is provided in appendix A of this report. In addition, a summary of the conditions that were described at each site in EPA reports (6,7) is included. This summary should be considered an underestimate of the true nature of the contamination found at the current (NPL) sites due to the inconsistencies in reports across states and the vague and preliminary nature of many of these descriptions. The list does provide, however, a crude estimate of the extent of contamination found at the 703 (NPL) sites around the country.

Recent estimates from the EPA indicate that nearly 2,000 waste sites eventually will require Superfund cleanup (3). A report from the Office of Technology Assessment (OTA), however, has indicated that the EPA has grossly underestimated the future requirements and that over 10,000 hazardous waste sites will require cleanup (3). The OTA report summarized data regarding solid waste facilities which indicated that their estimate of 10,000 sites should be considered conservative. The OTA estimated that there are currently 621,000 solid waste sites in the nation. This includes 36,000 municipal landfills (like the Midway Landfill), 225,000 industrial landfills and 340,000 surface impoundments. A conservative estimate of the likelihood of release of hazardous waste from these sites, 5% for landfills and 1% for surface impoundments, results in over 17,000 sites requiring future cleanup (see Table 1). Finally, the cost of cleaning the estimated 10,000 hazardous waste sites, according to the OTA report, "could easily be \$100 billion" and "could take 50 years" to accomplish.

A report presented by Dr. John Anderson from the Centers for Disease Control at the 1986 meeting of the Population Association of American (8) summarized data regarding the geographic distribution and demographic characteristics of communities surrounding hazardous waste sites. Using statistics from the 1980 census and geographic information for 786 hazardous waste sites that were included or proposed for the (NPL) on October, 1984, Dr. Anderson estimated that nearly half of the U.S. population lives in a county with a (NPL) waste site. The percent of counties with (NPL) waste sites was lowest in the south (29%) and highest in metropolitan areas (32%), in the Northeast (44%) and the West, where 2 persons in 3 live in a county with a (NPL) waste site. Using the 1980 census statistics and Zip Code information, Dr. Anderson also calculated that 193,000 children under the age of one year, 3 million reproductive age women, 1.3 million persons over the age of 65 years, and 2.2 million persons near or below the poverty level live in a Zip Code area with a (NPL) waste site. Dr. Anderson emphasized that very few persons living in these geographic areas are currently exposed to toxic wastes. He concluded, however, that the statistics do indicate that a very large proportion of the U.S. population could potentially be affected by hazardous waste sites.

B. Issues Related to the Evaluation of the Public Health Consequences of Hazardous Waste Sites

The purpose of this section is to provide a review of the scientific literature related to the evaluation of the health consequences of hazardous waste sites. There have been several independent articles and proceedings from at least three conferences published related to this topic in recent years. In addition, four major reviews of hazardous waste site community health studies have been published during the past two years. These articles include the following major points:

- The scientific principles associated with defining the health effects of toxic exposures should be utilized in health studies of hazardous waste site communities.
- The decision to perform health studies of hazardous waste site communities is often based more on social and political issues than on scientific factors.

- Health studies of hazardous waste site communities are often part of public service programs that do not meet rigorous scientific standards.
- Health studies of hazardous waste site communities have repeatedly demonstrated increases in subjective illnesses (e.g., headaches, respiratory distress, nosebleeds, etc.) that may be influenced by recall bias.
- Most health studies of hazardous waste site communities have not produced scientific evidence relating serious health effects to hazardous waste sites.
- Due to limitations in past study designs, sample sizes, and statistical approaches, the lack of scientific evidence relating serious health problems to hazardous waste sites may not provide an accurate assessment of the potential health effects of these sites.
- Future studies of hazardous waste site communities should utilize new techniques in exposure and outcome assessment, longitudinal study designs, and innovative statistical approaches in place of "the fastest or cheapest" procedures.

The scientific principles involved in assessing the human health effects of toxic exposures in the workplace and environment have been published in numerous books and articles in the areas of Toxicology, Occupational and Environmental Medicine, Environmental Epidemiology and Risk Assessment (9-12). A major review of the methods for examining the effects of toxic substances on human health entitled "Guidelines on Studies in Environmental Epidemiology" was published in 1983 by the World Health Organization (13). The appropriate use of various study designs including case registries, surveys or cross-sectional studies, prospective or follow-up studies, retrospective studies, and case-control studies are discussed in this report. Methods for the assessment of exposures, the measurement and interpretation of various health effects, and the statistical analysis of exposure-outcome data are also included. An in depth review of all of these issues is beyond the scope of this report. Methods directly relevant to previous studies regarding the health effects of hazardous waste sites, however, are reviewed in the appropriate sections below.

The requirements for a rigorous epidemiological evaluation of the human health effects of hazardous waste sites were reviewed in a series of articles published from a 1981 conference on "Research Needs for Evaluation of Health Effects of Toxic Chemical Waste Dumps" (14). An article in this series by Landrigan (15) summarized four principles which should guide the evaluation of persons exposed to hazardous wastes. These principles included (i) the documentation of the nature and extent of the exposure, (ii) the precise definition of the exposed populations, (iii) the specific diagnoses of the disease in the exposed (and control) populations, and (iv) the rigorous evaluation of the relationship between exposure and disease which, if possible, should include the detection of any dose-response relationships. In addition, results of toxic waste studies which indicate a significant increase in the prevalence of disease should be biologically compatible with known toxic effects of the chemicals, while negative results should be considered in light of the size of the population examined (e.g., the power of the study to detect differences) and the latency period for the disease to occur. The author recommended that methods for documenting exposure should include estimates of both daily dose and the duration of exposure and that the most useful exposure estimates are those that are specific for each individual in the population. In addition, it was recommended that outcome measures should be precisely targeted and include only those procedures that are both specific and sensitive.

Other articles in the conference series (16-21) and later publications (22-25) provided discussions of the above principles in light of the practical limitations of community health studies associated with hazardous waste sites. An article by Selikoff (19) included this assessment of hazardous waste health studies, "It is tempting to regard the problem of investigation of health hazards associated with toxic chemical wastes as almost insoluble at present. Exposures are poorly defined, disease patterns are not well identified, the relation of effects in other biological systems to illness in man is not understood. Neither the "dose" nor the response has been established and certainly not quantitatively." To help overcome these problems, Selikoff suggested that new approaches such as sero-epidemiology, biochemical epidemiology, and epidemiological immuno-toxicology should be used in traditional study designs like large scale prospective population studies and case-control studies of heavily exposed groups. The author indicated that to

successfully respond to the problems associated with hazardous waste sites "either we are going to have to change the toxic chemical waste dump sites or we are going to have to change epidemiology."

A report in the conference series by Neutra (18) and a report by Anderson (22) also describe the various problems related to community health studies and suggested principles of "dumpsite" or "reactive" epidemiology. Anderson indicated that while fulfilling the criteria for a scientific study can maximize the likelihood of a successful investigation, the "reactive circumstances" associated with hazardous waste sites usually dictate that you "do the best you can with what you have and make the most of the circumstances faced." Normally, community health studies do not have to meet rigorous scientific criteria to be funded due to social and political concerns. These studies are also largely "service programs rather than elective research" (22) and the constraints on study design, population size, and interpretation of results make them very different from conventional epidemiological studies. The success of these studies, according to Anderson, lies in their ability to combine processes for effective communication with the community with sound scientific procedures. Recommendations for further research in this area included the development of a national system to link existing data bases regarding health outcomes and geographic coordinates and the establishment of a cluster surveillance system to help standardize procedures and coordinate data collection and analysis across different hazardous waste sites. Finally, Anderson suggested that while community health studies will continue to provide a public health service for specific communities "Epidemiologists outside the health departments need to develop the analytical research opportunities and help design the data base tools necessary to meet the challenge of advancing our understanding of disease causation, to improve our ability to accurately assess the health risks posed by toxic chemicals and waste sites and to focus public reaction appropriately".

One of the most comprehensive descriptions of the typical situation one finds in communities that have voiced concerns about living near a hazardous waste site was provided by Dr. Raymond Neutra from the California Department of Health Services (23). Dr. Neutra wrote, "Hazardous waste dumpsite epidemiology has up to the present been primarily controlled by prolonged demands for investigation by the affected communities. By the time the epidemiologist arrives on the scene, years may have gone by, and the various

factions in the community are often at odds with each other and distrustful of any outside official whom they fear may continue to play down or even cover up any health effects of the site." According to Neutra (18,23), these situations require the practical public health functions of epidemiology such as providing timely reliable quantitative information about alleged problems in the community, separating the facts regarding community complaints from rumors, and communicating environmental and public health information to the community to place their fears in proper perspective. Since most hazardous waste studies cannot provide definitive resolution of the community's health concerns, Neutra suggests that the "early and continuing involvement of various community factions is essential to make sure that the community has enough input into the process of the study and the interpretation of results to assure themselves that a good faith effort has been made." This process is discussed in more detail later in this report in the section regarding state programs (see section III-B).

There have been four major reviews of hazardous waste site community health studies published during the past two years (26-29). A list of (NPL) sites included in these reviews (along with this review) is shown in Table 2. The review by Buffler et. al., (26) contains a tabular summary of (i) adverse health effects (and target organs) in humans due to chemical exposure, (ii) selected waste chemicals and their adverse health effects, and (iii) thirty-one episodes of environmental exposure to chemicals from point sources. The review does not attempt to evaluate the source of data for these tables and should be considered more as a reference source than a critical review of previous studies related to community health.

The reviews by Levine and Chitwood (27) and Phillips and Silbergeld (28) also contain a tabular summary of public health investigations of hazardous waste sites (19 and 32 sites respectively). Both reviews contain information regarding the study design, outcome measures, and the number of subjects studied, while the review by Levine also includes information regarding the impetus for the study, the exposure criteria, the agencies involved in the study and whether litigation is occurring at the various sites. Neither review contains a detailed evaluation of each community health study, although some general comments and conclusions are included. The comments of Levine and Chitwood (27) relate more to the possible reasons for the "silence of

public health investigators" than the quality of previous studies. The authors state that "public health investigation of hazardous waste disposal has yielded a vanishingly small crop of peer reviewed work" and that "investigations available for discussion are uniformly unconvincing about whether or not organic chemical hazardous waste sites are harmful to people". The authors recommend that a more balanced approach of reactive studies for specific community concerns with the "active identification and pursuit of important community diagnostic targets would be more in keeping with the traditional charge of public health and would enhance the likelihood of achieving more meaningful results."

Phillips and Silbergeld (28) indicate in their review that "epidemiologists and policy makers should be concerned about the limitations of present studies because the results are likely to represent an inaccurate picture of health status in exposed groups". The authors suggest that limitations in study design (cross sectional instead of longitudinal) health outcomes (most severe outcomes instead of subtle effects) sample size (too small), and data analysis (exposure vs control analysis instead of cluster designs) are common to the majority of studies performed to date. Recommendations such as the use of exposure registries, new biological indicators of dose and response (e.g., DNA adducts) and the use of cluster designs and analyses were proposed to improve the quality of health studies and provide a better understanding of the effects of hazardous waste sites on nearby communities.

The most comprehensive review of hazardous waste site community health studies is a book entitled "Health Aspects of the Disposal of Waste Chemicals" (29). The contents of this book include a summary of chemicals reported at (NPL) sites, an overview of various health assessment procedures, a review of health effects from occupational exposure to chemicals, and a review and critique of twenty-one community health studies. The authors concluded from their review that only one study (30) provided sufficient scientific evidence indicating that serious health effects (gastro-intestinal distress, neuropathy) had resulted from exposure to a specific chemical (arsenic). The authors indicated that the increase in subjective symptoms (i.e., headaches, eye irritation, respiratory distress) reported in several studies could have been caused by "participant bias" due to heightened concerns among residents and that these results do not establish a causal association between waste

sites and various subjective illnesses. The authors recommended that additional prospective and retrospective health studies be performed and that "interdisciplinary teams of scientists should be used in future studies of health effects associated with chemical disposal sites." According to the authors, disciplines relevant to these studies include, but are not limited to, epidemiology, public health medicine, toxicology, environmental science and engineering, and biostatistics.

It is clear from the above reviews that very few general conclusions regarding the health effects of hazardous waste sites can be offered at this time. Reports of increased rates of subjective or nonspecific illness in hazardous waste site communities are considered significant by some, while others stress the limitations of self reported data. The lack of evidence linking hazardous waste sites with serious disorders (e.g., cancer, birth defects) and death may only be relevant for the short term, yet current studies do not provide adequate follow-up data. Although new technologies may assist in the future determination of individual exposures and affects, current methods for identifying exposed members of the community are extremely nonspecific. The only consistent conclusion that has been offered thus far is that there is a critical need for more data concerning the health effects of hazardous waste sites. However, approaches that are being utilized to address this critical need, like those reviewed below, vary as greatly as the current assessment of the waste site situation.

III. Federal and State Programs

The purpose of this section is to provide a review of federal and state policies as they relate to the collection and use of public health information from hazardous waste site communities. In addition, a citizen's group approach to this issue is reviewed and compared to current federal and state programs. The major points include:

- The potential public health consequences of hazardous waste sites play a major role in EPA decisions to include sites on the (NPL) for cleanup.
- The primary health aspect of the EPA Remedial Investigation Program involves the development of a public health evaluation of the site.
- Current EPA guidelines do not emphasize aspects of the public health evaluation of the site that would necessitate surveying the hazardous waste site community.

- The Agency for Toxic Substances and Disease Registry (ATSDR) was created by Superfund Legislation to implement the health related authorities of the program.
- Current EPA and ATSDR guidelines for requesting health assistance from ATSDR require a considerable amount of data concerning the type and extent of contamination from the site, as well as specific data regarding human exposures.
- As a result of the above, decisions regarding the type and extent of monitoring prior to and during the remedial investigation of the site usually takes place without ample public health representation.
- Current ATSDR criteria for performing health studies or developing registries of hazardous waste site communities require that measurable levels of hazardous agents indicating the time period and level of exposure be available or obtainable.
- The above required criteria, as well as others, are rarely met and ATSDR typically does not include studies of hazardous waste site communities in their health evaluation of the site.
- To date, only a few long term follow-up studies and no registries of persons exposed to hazardous waste from (NPL) sites have been developed by ATSDR.
- Current State Programs regarding hazardous waste site communities vary from state to state but usually include a review of state registry and vital statistics records for the community.
- States that have included community health surveys in their program have always done so as a result of pressure from potentially affected communities.
- Community health surveys are typically only one facet of a general program designed to promote community involvement in major decisions regarding the site.
- Most state sponsored community health surveys have utilized surrogate measures of exposure due to the lack of information regarding individual exposures to hazardous wastes.
- Most state sponsored health surveys have utilized self reported symptoms (as well as more serious diseases) to measure the potential impact of the hazardous waste site on the community.

- Most state sponsored health surveys have indicated that hazardous waste site communities report an exacerbation of common symptoms. The underlying causes of these exacerbated symptoms usually are not determined.
- The Citizen's Clearinghouse for Hazardous Wastes approach to the issue of health surveys of hazardous waste site communities is to refrain from demanding a definitive study of the cause of the health problems in the community and to emphasize the need to define the type and extent of health problems as an initial step in the environmental and health investigating process.

A. Federal Programs

The 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authorized the EPA to direct the Superfund Program. In addition, the act called for the creation of a new agency under the Department of Health and Human Services (DHHS) called the Agency for Toxic Substances and Disease Registry (ATSDR). While the EPA was given the major responsibilities regarding hazardous waste site identification, investigation, and cleanup, the ATSDR was given the responsibility to "effectuate and implement the health related authorities of the act" (1). The policies of these agencies as they relate to the evaluation of the public health of hazardous waste site communities are reviewed below.

1. The Environmental Protection Agency

The EPA hazardous waste Superfund Program was initiated to identify and clean up those waste sites that may represent a threat to public health or the environment. To this end, the EPA process includes an assessment of the potential public health impact of each site that is considered for the National Priority List (NPL). A preliminary assessment of each site results in a decision to (i) take no action, (ii) respond to an imminent threat by immediate removal action, or (iii) perform more extensive studies to evaluate the need for remedial action (4). Those sites that may pose a long-term threat to public health or the environment are ranked according to EPA's Hazardous Ranking System (HRS). The rating factors used by EPA in the (HRS)

include: (i) whether there has been an observed release of hazardous waste, (ii) what are the characteristics of the sort(s) of release (e.g., air, groundwater, etc.), (iii) what kind of containment exists to minimize the release, (iv) what are the characteristics of the hazardous wastes (e.g., toxicity, persistence, quantity), and (v) what are the potential targets of the release (e.g., size and distance to nearest community, sensitive environments) (31). The (HRS) produces three scores: the first score indicates the likelihood of hazardous waste migrating off of the site and reaching nearby communities. The second score reflects the likelihood of people coming in direct contact with the hazardous wastes, and the third score indicates the possibility of a fire or explosion occurring due to the hazardous wastes. Only the first score is used to rank the site on the (NPL) list. The second and third scores are used to identify sites that are imminent threats where removal actions are needed (4). The potential public health consequences of the hazardous waste site, therefore, play a major role in decisions to include sites on the (NPL) for cleanup.

The assessment of the potential public health consequences of the hazardous waste site is also an important part of the Superfund Remedial Program (32). The Remedial Program has two phases, the remedial investigation and the feasibility study. During the remedial investigation, information regarding the nature and extent of contamination at the site is collected and analyzed following the procedures discussed in the EPA document "Guidance on Remedial Investigations under CERCLA" (33). Once the nature and extent of the contamination is determined, the Feasibility Study is performed to recommend alternatives for cleanup according to the procedures outlined in the EPA document "Guidance on Feasibility Studies Under CERCLA" (34). The Remedial Investigation/ Feasibility Study (RIFS) can be developed under the direction of the EPA or the state where the hazardous waste site is located. The party responsible for the hazardous waste site can also be involved in developing the RIFS, negotiating with the EPA or the state. EPA policy regarding public participation in this process, according to an OTA report (3), "is to exclude the public from all negotiation sessions (regarding the RIFS), but to provide periodic information about the progress of negotiations."

The primary health aspect of the RIFS involves the development of a public health evaluation of the site. The public health evaluation includes a baseline site evaluation, an exposure assessment, a standards analysis, and

the development of remedial alternatives to minimize risk. The exposure assessment evaluates the frequency, magnitude, direction and potential effects of human exposure to hazardous waste released from the site. A list of questions that should be addressed by the exposure assessment is shown in Table 3. Some of these questions require information concerning potentially sensitive groups in the community (children, elderly, the sick) or documentation of health problems that have been alleged or proven to be related to the site (see Table 3, Questions IIA-2, IIB, IIID-1). Current EPA guidelines, however, do not emphasize these issues in the exposure assessment.

Activities related to hazardous waste site communities are usually limited to those included in a public relations program, which focuses on disseminating information regarding the site investigation.

In addition to the public health evaluation, EPA or the state can request the assistance of the ATSDR for health assessments or health studies. According to a memorandum of understanding between ATSDR and EPA (35), the criteria that should be used for requesting assistance from ATSDR includes: "Whether the presence of toxic substances has been confirmed at the site, whether pathways of human exposure to toxic substances have been demonstrated to exist at the site, especially if such pathways involve direct contact with toxic substances, and whether a human population has been exposed to toxic substances via the identified pathways, and whether there exists a threat of current or future health effects to the population being so exposed, after considering EPA's risk assessments or health effects information from other sources." These criteria require a considerable amount of data concerning the type and extent of contamination from the hazardous waste site, as well as specific data regarding human exposures. The RIFS process provides this data very slowly (sometimes over several years) and in many instances this process does not provide this data at all (because exposures may be transient, episodic, or poorly documented). Formal requests for assistance from ATSDR, therefore, usually do not take place until very late in the RIFS process, after the environmental investigation of the hazardous waste site is complete. Currently, there are no EPA regulations requiring ATSDR or local health experts to participate in developing the RIFS process. Decisions concerning the type and extent of monitoring for possible past and present human exposures to hazardous wastes, therefore, usually take place without community or public health representation.

2. Agency for Toxic Substances and Disease Registry/ Centers for Disease Control

The Agency for Toxic Substances and Disease Registry (ATSDR) was established in 1983 following a successful lawsuit by the Environmental Defense Fund, the Chemical Manufacturers' Association, and the American Petroleum Institute against the Department of Health and Human Services (DHHS). The basis of the lawsuit was DHHS's failure to establish ATSDR and to implement its functions (36). The functions of ATSDR, as defined by the CERCLA legislation, include (i) in cooperation with the States, establishing and maintaining a national registry of serious diseases and illnesses and a national registry of persons exposed to toxic substances; (ii) establishing and maintaining an inventory of literature, research, and studies on the health effects of toxic substances; (iii) establishing and maintaining a complete listing of areas closed to the public or otherwise restricted in use because of toxic substance contamination; (iv) in cases of public health emergencies caused or believed to be caused by exposure to toxic substances, providing medical care and testing of exposed individuals, including but not limited to tissue sampling, chromosomal testing, epidemiological studies, or any other assistance appropriate under the circumstances; and (v) conducting periodic survey and screening programs to determine relationships between exposure to toxic substances and illness.

Criteria for performing health studies of hazardous waste site communities or developing Exposure/Outcome Registries of persons exposed to hazardous waste have been proposed by ATSDR and the Center for Environmental Health (CEH), Centers for Disease Control (37-39). A CEH report published in 1984 (38) included a checklist of criteria for use in assessing the feasibility of health studies of hazardous waste site communities (see Table 4). According to this report, health studies should be considered feasible (i) when biological levels indicating the time period and level of exposure are available or can be obtained; (ii) when the possible effects of the exposure are known, based on human data; (iii) when the health effect is relatively specific or is caused only by the exposures; (iv) when enough people are exposed to allow statistically valid conclusions from the study; and (v) when adequate resources and local cooperation are available.

A Health Study Plan prepared by ATSDR (37) also included information concerning priority health studies. Two categories of studies were reviewed; Exposure/ Body Burden Studies and Health Outcome Studies. Priority factors for Exposure/Body Burden Studies included: (i) the Ability to Measure and/or Interpret Body Burden (studies that measure the amount of a substance in the body, the persistence of the substance in the body, and whether the body burden can be correlated to a health effect); (ii) Substance(s) of Concern (with highest priority given to those substances found at sites listed on the National Priority List); and (iii) Reference Range Studies (Nationwide surveys to determine levels for toxic substances in the population to serve as "reference value ranges" for assessing human exposure). The types of Health Outcome Studies that were listed to have priority included: (i) Surveillance Systems (studies that measure end effects such as reproductive effects or sentinel diseases, i.e., those diseases that serve as the prototype of the effects that would be expected from a given exposure); (ii) Target Organ Studies (studies that utilize a test, or series of tests, to determine whether adverse effects are occurring to a particular organ or organ system of the body); and (iii) Cohort Studies (studies that look for evidence of adverse health affects in exposed populations and in particular at-risk groups such as workers, children, pregnant women, elderly, etc.).

The above Health Study Plan, as well as a report prepared by CEH for ATSDR (39), also defined the priorities for establishing Exposure/Outcome Registries. These priorities included: (i) Studies of persons exposed to hazardous agents for which current methods exist to prevent/mitigate an adverse health outcome, or where there is an expectation that new medical breakthroughs will soon lead to such prevention/mitigation methodology; (ii) studies of persons exposed to persistent, measurable levels of hazardous agents in which animal studies or other evidence predicts significant toxic effects in humans; or (iii) studies of persons with adverse health outcomes where measurements of exposure to hazardous agents are available.

The above criteria regarding health studies and registries were developed, according to the ATSDR Health Study Plan (37), because so little information exists regarding the effects on humans of long term low level exposure to chemicals or chemical mixtures. These criteria, according to this

plan, prioritizes those studies that will have the greatest impact for establishing a relationship between chemical exposure and illness. These criteria, however, are rarely met at hazardous waste sites and ATSDR typically does not include studies of health problems of waste site communities in their health evaluation of sites. In addition, these criteria, like those of EPA, do not provide the impetus for early and continued public health input into the site investigation process (RIFS), even though it is this process that will eventually determine the public health impact of the site on the nearby community. While ATSDR and CDC have conducted or participated in studies at several (NPL) sites (see review below for some examples), these studies usually were limited to the collection of biological samples for establishing exposure to chemicals and cross-sectional procedures to evaluate health effects. Few follow-up studies have been performed to date, and thus far no registries of persons exposed to hazardous waste from (NPL) sites have been developed by ATSDR.

B. Health Department Programs

While the federal programs described above were developed to address health issues at hazardous waste sites, the primary responsibility for responding to questions, requests, and demands of hazardous waste site communities still rests at the state and local health department level. To this end, ATSDR typically does not become involved in local health issues unless invited to do so by the state. Programs developed by state and local health departments to address community health concerns are of paramount importance then, since these programs will ultimately determine the type and scope of the response.

Information regarding the state programs reviewed below was obtained via three procedures; (i) by reviewing published articles of health studies of hazardous waste site communities; (ii) by reviewing unpublished articles from health department files; and (iii) by a telephone survey of 18 state health departments. The telephone survey was not conducted to present an unbiased assessment of the "typical" state program nor does it present an exhaustive list of current state activities. A summary of the information obtained by the telephone survey is shown in Table 5. This information is also included in Table 2, with a summary of other studies that have been previously reviewed (26-29).

While various approaches have been utilized across the states surveyed, a few general principles can be stated. Nearly all of the health departments surveyed indicated that (i) local community representatives had requested information and/or studies regarding the health problems in a hazardous waste site community; (ii) the state health department typically takes the lead in responding to these requests due to the limited resources at the local level; (iii) in response to these requests, state registries and/or vital statistics records are initially reviewed to investigate serious health problems such as cancer, birth defects, and mortality; (iv) health studies of hazardous waste site communities are almost always initiated by pressures from the potentially affected community; and (v) health studies of hazardous waste site communities are typically part of a larger public health program designed to provide a format for continuous communication between the health agencies and the community. Finally, for those states that have sponsored large scale community health studies, the resources for these studies have always come from funds from State Superfund Programs. These programs were initiated to provide resources to assist site cleanup, as well as to support local health related activities at the various waste sites. A review of the state programs and studies is presented below.

ALABAMA - The Alabama State Health Department has participated in two health studies of hazardous waste site communities with the CDC. Dr. Wallace Birch, from the state health department, indicated that the state did not have the resources to conduct large scale health studies and that cooperation with CDC was the appropriate approach. Health studies have been conducted at the Triana/Tennessee River and the Interstate Lead Company sites. The procedures and results of the Triana study were published in 1981 (40), details of the Interstate Lead Company study are not available at this time. The Triana/Tennessee River Study provided a cross-section investigation of residents exposed to DDT residues discharged by a local manufacturing plant. The average serum DDT levels for the 499 persons examined was over five times the national average. Residents were exposed to DDT residues via consumption of contaminated fish. Serum DDT levels increased with age and were significantly related to race, sex, fish consumption, years residence, socioeconomic status, alcohol consumption, and serum triglyceride levels. No acute health effects were associated with DDT exposure, although possible DDT effects on lipid

metabolism and liver function were indicated. Procedures to assess potential chronic health effects were not included in this study. The authors recommended that efforts to reduce human exposure to DDT should be implemented. No recommendations regarding follow-up studies of those exposed to DDT were included.

ARIZONA - The Arizona State Health Department, according to Dr. Norman Peterson, has reviewed data regarding birth defects, cancer, and mortality for several hazardous waste site communities in the state. In addition, the health department has participated in studies at the Mountain View Mobile Home Estates site (41,42) and the Tucson International Airport Area site (43,-46). The Mountain View Study, conducted with CDC, was published in 1981; unpublished reports concerning the Tucson Airport site were received from Dr. Peterson. The Mountain View Study examined the potential asbestos exposure and health status of residents in a subdivision constructed on an asbestos mill. Asbestos fibers were found in soil, indoor and outdoor air, dust and personal air samples. Residents of the community were temporarily evacuated, properties were decontaminated and new soil was brought in to cover all open land. A survey conducted by the State Health Department indicated that none of the residents had known asbestos-related diseases. Because of the asbestos exposure, however, the health department began an extensive anti-smoking program for all residents and urged all families to notify their physicians of their asbestos exposure and to obtain baseline clinical exams. An EPA update report of this site (42) indicated that the new soil had been eroded exposing the asbestos tailings again. EPA has adopted a permanent relocation remedy for this site and has offered temporary relocation for all residents until the permanent relocation can be implemented. While the original report indicated that one purpose of the health department survey was to identify all residents for follow-up, no information regarding follow-up studies was included in the original or the updated report.

Studies at the Tucson Airport area site were initiated in response to community concerns over the ingestion of water contaminated with Trichloroethylene (TCE). The source of the contamination was a missile manufacturing facility owned by the Air Force and operated by Hughes Aircraft. Unpublished reports received from the Arizona State Health Department included (i) a 12 year review of vital statistics death records, (ii) a 5 year review of birth defects from hospital records and birth certificates, (iii) a 7 year

review of school attendance records, and (iv) committee recommendations for follow-up studies of residents exposed to contaminated drinking water.

The mortality and birth defects studies compared data from census tracts associated with the contaminated drinking water with tracts similar in socio-economic characteristics. Mortality statistics were also compared to state, county, and United States figures while birth defect rates were also compared to statistics from the CDC. Results of the mortality and birth defects studies did not indicate excess deaths or birth defects in census tracts associated with contaminated drinking water. While some causes of death and some birth defects were elevated in the census tracts associated with the contaminated drinking water, similar results were obtained from the control census tracts.

The study of school attendance examined admission records to Homebound Programs for the Sunnyside School District, located near the TCE contaminated wells and a control school district. Homebound Programs were established to provide instruction outside the classroom for students who could not attend school for three months or more. Results of this study indicated that for 7 to 12 diagnostic categories, the Sunnyside School District had significantly higher Homebound admission rates. The authors concluded that due to limitations in the study design and the type of diagnoses that were increased, no difference in Homebound admission rates suggestive of specific health problems were observed. The authors also concluded that there was no evidence from the study linking the occurrence of adverse health effects to TCE exposure in the Sunnyside School District.

In addition to the above studies, the Arizona Health Department established a review committee for the Tucson Airport area site. The recommendations of this committee were submitted to the Director of the Arizona Department of Health Services on June 20, 1986. The committee listed several alternatives for follow-up studies of Tucson area residents including Statewide Birth Defects and Cancer Registries, Case-Comparison Studies of specific diseases, Cohort Studies (both retrospective and prospective) exposure measurements, random sample surveys, and workplace studies. The committee gave a high priority to establishing statewide birth defects and cancer registries, case control studies of childhood leukemia and testicular cancer (based on previous press reports), a pilot study to determine if exposure could be measured in exposed persons, and a random sample survey of

current residents stratified by length of residence. The committee also recommended that a community committee be formed with representatives from local organizations, the EPA, and the state, county, and city health departments. The purpose of the community committee would be to review and disseminate information regarding remedial action plans and health studies, to act as a liaison between the community and government agencies and to arrange for meetings to report the results of studies to the public. All of the recommendations of the review committee are currently under consideration at the State Health Department.

ARKANSAS - The Arkansas State Health Department, according to Dr. Tom McChesney, has recently participated with CDC in an exposure survey of residents near the Vertac, Inc. site (47). This survey was prompted by health concerns of residents near the site following reports of insecticide, herbicide, chlorinated phenol, and dioxin contamination of the soil, groundwater, and air. The objective of the exposure survey was to evaluate if increased exposure to herbicides had occurred in children 2 to 6 years of age in the community near the Vertac site. Urine samples from 100 children from the Vertac community and a control community were collected and analyzed (by CDC) for 11 chemicals related to herbicide exposure. No assessment of health problems in the community living near the site was included in this survey. To date, the results of the urine analyses were not available for review.

CALIFORNIA - The California State Health Department is probably one of the most active state health departments in the country in the area of hazardous waste site community health studies. Dr. Raymond Neutra, head of the State Health Protection Program, has been extensively involved in this area for several years and has advocated specific principles of "dumpsite" epidemiology in a recent report (18). This report (see section II-B), emphasizes the practical public health functions of epidemiology (i.e., providing timely, reliable, quantitative information about alleged problems in the community) and the importance of early and continued community involvement in the health assessment process (since definitive resolution of health concerns is not likely). These principles are clearly reflected in previous state health department activities related to hazardous waste site communities. In the past 5 years, the state health department has participated in several community health committees, has conducted large scale community health studies at 5 hazardous waste sites (48-54), has conducted a

reproductive dysfunction and cardiac birth defect study at one site (55-57) and has contracted for independent cancer risk and exposure assessments at another site (58-60). The 5 large scale community health studies were conducted at the McColl, Stringfellow, Operating Industries, Del Amo, and Purity Oil sites. Thus, far, the final reports of only the McColl and Stringfellow studies are available for review.

The McColl Site Health Survey (48,49) consists of (i) an adult health survey, (ii) a pediatric health survey, (iii) a reproductive outcomes survey, (iv) a pet health survey, and (v) a toxicological review of airborne emissions and on-site contaminants. The survey was conducted in response to complaints of odor and bothersome symptoms from the community near the McColl waste disposal facility. According to the authors of the survey, "the premise for the investigation, was that airborne chemical emissions from the site might be causing adverse health effects." The objectives were to "(i) document the extent of the odor problem, (ii) document the extent and severity of bothersome symptoms, (iii) assess the patterns of medical care utilization to see if symptoms or illnesses severe enough to warrant medical care were excessive in the McColl neighborhood, (iv) assess the incidence of malignant and benign tumors in the residents living around the site, (v) assess the incidence of untoward reproductive effects, and (vi) assess the incidence of mortality and cancer among pets, whose shorter life span and potentially greater exposure to the site, may serve as useful indicators for problems which might develop in humans later on."

All health survey information was collected via a self-administered questionnaire following a census of the McColl community and two nearby control communities. Adult members of the McColl and control communities were instructed to complete their own questionnaire, while information for children under 16 years of age was provided by an adult member of the family. One thousand and twenty four adults (82% of the McColl and 69% of the control residents) and 488 children (73% of the McColl and 64% of the control residents) responded to the survey. At least one person responded in over 90% of the families in both communities. All questions addressed the occurrence of symptoms and disease since moving to the respondents current address. A wide variety of symptoms and disease were covered (see Table 6). Results from the McColl community were divided into 5 separate "odor zones" ranging from "no odor-detected" to "odor often very strong."

The Adult Health Survey indicated that 18 of the 24 symptoms reported (see Table 6) were more frequent in the McColl community. These symptoms increased with increasing severity of reported odors. The increased reported symptoms did not result in a significant increase in the utilization of doctors, emergency rooms, or hospitals. The increase did, however, influence the communities perception of it's overall health status, with significantly more respondents reporting that their health had worsened since moving into the community. Results related to the occurrence of benign and malignant tumors did not indicate a significant increase for the McColl community.

The Pediatric Health Survey also indicated an increased frequency of reported symptoms (18 of 27 symptoms) which increased with increasing severity of reported odors. No significant increases in reported symptoms of hyperactivity, dyslexia or other medical problems (including benign and malignant tumors), however, were found for the McColl children. In addition, the growth rates and parental evaluations of social and academic skills of the children were similar in the McColl and control communities. Finally, the McColl children tended to see physicians more frequently than children from the control area and parents of children in the McColl community evaluated the overall health of their children as poor more frequently. This increase in poor health evaluations reflected the higher number of symptoms per child reported for the McColl children.

The results of the Pregnancy Outcome Survey did not indicate a higher incidence of infertility, birth defects, stillbirths, miscarriages or low birthweight infants for the McColl residents. More women in the McColl community, however, did report menstrual disturbances, with irregular menstrual periods clearly related to odor zone within the McColl neighborhood.

The Pet Health Survey examined the rates of mortality in dogs, cats, and birds in the McColl and control communities, as well as the incidence of benign and malignant tumors. The results did not indicate a greater rate of mortality or incidence of tumors for pets in the McColl community.

A toxicological review of the airborne emissions at the McColl site by the California Health Department indicated that nearly 50 substances present in the air during odor episodes could be attributed to the site. The concentrations of these substances during odor periods were higher than typical background levels, although, according to the health department, none were at levels that should produce detectable toxic, teratogenic or carcinogenic effects.

A toxicological evaluation of the chemicals located on the McColl site by the health department indicated that a significant potential public health hazard existed from direct contact with the petroleum wastes. The Health Department also indicated that there was reason to be concerned about the potential health effects from direct contact, since current conditions had not deterred children from entering the site.

The survey, according to the authors, succeeded in meeting its objectives and provided important information about a number of community concerns. The results of the survey demonstrated that the ambient air in the McColl community was being impacted by the low levels of petroleum-related chemicals being released by the site. These chemicals and related odors from the site had adversely affected the McColl community's perception of their health by increasing the incidence of a number of "bothersome" symptoms. The results also indicated that current cases of cancer and poor reproductive outcomes in the community were not part of an epidemic but were at levels that would be expected for the community. The authors concluded that the quality of the ambient air in the McColl community should be improved to a level comparable to the nearby communities. Mitigation of this problem, according to the authors, should decrease the rate of symptomatic complaints and should improve the assessment of overall health in the McColl community. Finally, based on the toxicological data, the authors concluded that there would not be a detectable increase in organ damage, cancer or poor reproductive outcomes (since, with the number of subjects available, a 5 to 20 fold increase in these outcomes would be needed) even if a lifetime follow-up study were performed.

The Stringfellow Health Effects Study was conducted by the University of California, Los Angeles under contract with the California State Health Department. The study consists of (i) a household health survey, (ii) a child health examination, and (iii) a review of medical and death certificate records. The study was conducted in response to community complaints and concerns about health problems associated with living near the Stringfellow Acid Pits. The Acid Pits contained large quantities of toxic chemicals and a series of heavy rains and floods had released contaminated water and soil from the site into the nearby communities. According to the authors, the study was designed primarily for hypothesis seeking "because of the possibility of both a wide range of outcomes and potential unique outcomes." The objectives were to (i) compare the rates of spontaneous abortion, congenital malformations,

low-birthweight and cancer in the Stringfellow community and a control community (ii) compare rates of minor and major malformations in young children from the Stringfellow and control areas, (iii) compare serum DDT, DDE and PCB levels in the same young children, (iv) compare the rates of a number of health problems and symptoms from households in the Stringfellow and control communities, and (v) establish a study group which could be followed to detect possible long-term effects.

All health survey information was collected via a face-to-face interview of the female head of the household using a 125 page questionnaire. Two Stringfellow communities and one nearby control community were surveyed. Six hundred and six households representing 3,328 individuals participated (81% and 91% of the Stringfellow households and 77% of the control household). The questionnaire included life-time histories of over 40 diseases; questions regarding the occurrence of 35 symptoms during the past 6 months, medical use during the past year and pregnancy histories and mortality since moving to the area.

The Household Health Survey indicated that 3 of 19 diseases reported for individuals 20 years of age and over were more frequent in one of the Stringfellow communities. No disease was reported more frequently for those under 20 years of age. The average number of symptoms reported per person was significantly higher in the Stringfellow communities and 3 of 24 symptoms (for adults) and 5 of 24 symptoms (for those under 20 years) were increased (see Table 7). The number of days of illness per person for the past year was also higher in the Stringfellow communities, although this did not result in an increased number of physician visits. The results of the health survey did not change when adjusted for the respondent's perception of the threat due to pollution or toxic waste. In addition, the results were not related to water usage or the length of residence. Finally, no significant differences in adverse pregnancy outcomes, birth defects, low birthweight or overall mortality were found between the Stringfellow and control communities.

The Child Health Examination did not indicate differences in the number of major or minor anomalies for children in the Stringfellow and control communities. Results of clinical laboratory and toxicologic examinations (DDT, DDE, PCB) were all within normal limits.

The results of the health survey, according to the authors, should be reassuring to the residents of the Stringfellow communities. Increases in the

incidence of severe health problems were not found and clinical or toxicological examinations of children did not indicate an increase in serum levels of toxic substances or abnormal blood parameters. Residents of the Stringfellow communities, however, did report more symptoms than those in the control community and several symptoms were reported more frequently. The authors indicated that these results may have been influenced by better recall or over-reporting in the Stringfellow communities due to a heightened awareness of their problems "since it would be unusual for such a wide variety of symptoms to increase as a result of chemical exposure." The authors also indicated that, regardless of the results and interpretation of the survey, the examination and cleanup of the Stringfellow site would continue. Follow-up studies that attempt to estimate likely levels of exposure using environmental data were considered to have a high priority, while studies to (i) determine the cost and feasibility of locating and following current or former residents, (ii) examine the cases of diseases which were reported at a significantly higher rate (i.e., ear infections, skin rashes), (iii) statistically examine if cases of birth defects, cancer, or deaths cluster geographically or in specific years, and (iv) follow all school children who resided in the area during or after the years of flooding were also listed. Funding for follow-up health studies of the Stringfellow communities has already been approved by the governor of California and details of these studies are being discussed at this time.

The response of the California Health Department to concerns of residents near the BKK Landfill in West Covina, California is most similar to the Midway Landfill situation. The BKK Landfill accepted municipal and hazardous wastes for nearly 20 years. Recent investigations of the site have indicated off-site migration of hazardous liquids and gases. Nineteen homes in the area around the landfill were temporarily evacuated in 1984 due to explosive levels of methane and other toxic gases have been found in the air. A gas extraction and monitoring system, ground-water monitoring wells and a closure plan are being developed to investigate the extent of the contamination and devise the remedial alternatives for the site. In March of 1985, Region 9 of the EPA began publishing a bi-monthly BKK update to "inform the community about activities, findings and issues of concern." According to reports from these updates, a coalition of homeowners in the BKK community has "requested a study of the short-term and long-term effects of exposure to

toxic chemicals to people who live near the site and those who previously lived near the site but have since moved." The coalition recommended that the study "be performed by independent contractors selected and managed by EPA and the California Department of Health Services." The coalition also recommended that a committee be formed to "assist in the development and approve the study plans prior to their implementation." In response to the community's concerns, the California Health Department has (i) established a work group to discuss issues related to the investigation of health problems of residents in the area, (ii) developed a report entitled "Ambient Air Monitoring and Health Risk Assessment for Suspected Human Carcinogens Around the BKK Landfill in West Covina (58)," (iii) awarded a contract to the University of Southern California for a further evaluation of cancer risk in the BKK Landfill community (59), (iv) provided dermatologic examinations of residents who have reported chronic skin rashes, and (v) awarded a contract to CH2M Hill for a BKK Environmental Exposure Characterization (60). The Health Department also has plans to conduct a Birth Certificate Study to examine birthweight, fetal death, and birth defect statistics for the BKK Community.

The ambient air monitoring and health risk assessment study (58) examined the ambient air concentrations of 9 volatile compounds at 5 residential locations in the BKK Community and one control location for over a three month period. The data from this monitoring program were evaluated in relationship to toxic, non-carcinogenic, and carcinogenic effects for the community. The results of the monitoring program indicated that the levels of 5 volatile compounds (vinyl chloride, tetrachloroethene, trichloroethene, vinylidene chloride, ethylene dichloride, and benzene) were elevated in the BKK community. The levels, however, were considered to be well below the threshold for toxic or non-carcinogenic effects and were associated with a maximum risk of 5 per 100,000 for carcinogenic effects. The results of the air monitoring program indicated, according to the authors, that no additional cases of cancer were to be expected in the community from exposure to date, that the individual cancer risks were relatively low and did not constitute a public health emergency and that further monitoring should be performed to define the specific on-site sources of emissions, to assess the normal variation of the levels and to evaluate the dilution of these levels at various distances from the landfill.

A more detailed carcinogenic risk assessment was conducted by the University of Southern California under contract to the California Health Department (59). The specific aims of this assessment are shown in Table 8. The methodology developed to meet the specific aims, according to the authors, could be used in evaluating the cancer risk in small communities and could "help prioritize dumpsite-neoplasm combinations on the basis of the degree of suspicion." The results of the assessment for the BKK landfill indicated that "the cancer experience in people living in the residential neighborhood adjacent to the BKK landfill does not appear to have been unusual." The authors indicated that for the census tract containing the dumpsite, the geographic, chronologic, and demographic patterns of neoplasms paralleled the patterns of cancer in the local population in the Los Angeles County. The authors recommended that reassessment of cancer statistics could be performed after several years and that case-control studies should be performed if any particular neoplasm does appear increased.

A work plan for a BKK Environmental Exposure Characterization has been submitted to the California Health Department by CH2M Hill (60). The Environmental Exposure Characterization is being developed in accordance with the objectives of the Superfund Endangerment Assessment (see Table 3) and will provide a preliminary evaluation of the health risks of the landfill site. The results of the Exposure Characterization, while not available at this time, should be available soon. Thus far, the coalition of homeowners in the BKK community have evaluated the effects of the health department in relation to their requested program. The issue of a community health survey is still under consideration at this time.

COLORADO - The Colorado State Health Department, according to Dr. Stanley Ferguson, has not conducted or participated in health surveys of hazardous waste site communities. The department has, however, conducted reviews of cancer registry information for some sites in the state. The specific sites reviewed were not specified and a report of the results were not available.

CONNECTICUT - The Connecticut State Health Department has worked with citizen groups around the Laurel Park site. A citizen group performed a survey of the community; the results, according to Carolyn Jean Dupuy from the Health Department, did not indicate health problems above normal. The Health Department has also performed an exposure evaluation of the site and has

examined grade school attendance in the area. The results, according to Ms. Dupuy, did not indicate a reason for concern. The EPA is now involved in site mitigation procedures and the focus of the citizens at this time is to get the remedial measures working.

DELAWARE - Dr. Lawrence Krone from the Delaware State Health Department indicated that the department works with the EPA in developing qualitative health assessments. Dr. Krone also indicated that the local CDC representative at the EPA is consulted regarding potential health problems associated with Superfund sites. The health department, according to Dr. Silverman, has conducted a survey to assess exposure in a community near the Delaware City PVC Plant site. A study to measure blood liver enzyme levels was also performed at this site. The results of the liver enzyme study were not available for review.

FLORIDA - The State Health Department in Florida, according to Dr. Thomas Atkenson, has been asked to review several surveys conducted by hazardous waste site communities. The Health Department has reviewed physician records at one site and has utilized cancer registry and hospital records to evaluate cancer and birth defect rates. The results of these reviews were not available for review.

GEORGIA - The Georgia State Health Department has participated in studies with the CDC for two waste site communities. The studies, according to Tom McKinley, included a survey of persons living adjacent to the sites in order to identify residents at high risk for exposure. This survey was followed by a biological monitoring study to measure metabolites of pesticides or levels of PCB in blood. The blood measurements were performed by the CDC. The results were not available for review.

IDAHO - The primary activities of the Idaho State Health Department, according to Dr. Charles Brokopp, have been associated with the Bunker Hill site. The health department participated in an extensive epidemiologic study of blood lead levels in children and the relationship of these levels to lead levels in various environmental compartments (61). The study was performed in cooperation with the Panhandle District Health Department, the CDC and the EPA as part of the Superfund investigation of the site. The study defined the various environmental sources of blood lead levels in children who lived near the Bunker Hill smelter but did not include a health evaluation of the children. The health department also participated in an earlier study

conductd by CDC at the smelter site (62). The purpose of this study was to "evaluate the prevalence, sources, and health consequences of lead absorption" among children living near the site. The results of the study indicated that blood lead levels in children were related to the duration of residence near the smelter, airborne lead levels, and lead levels in soil and dust. No clinical cases of lead poisoning were observed. Increased absorption of lead, however, was noted in children who lived near the smelter. Increased erythrocyte protoporphrin levels and anemia were also observed in these children. Finally, a significant negative correlation was found between blood lead levels and motor nerve conduction velocity. The results, according to the authors, were consistent with the results of other studies and indicated that "various subtle neurologic and psychologic abnormalities may develop in children with increased lead absorption." Further health studies of these children have not been reported to date.

IOWA - The Iowa State Health Department has used data from their state cancer and birth defects registry for investigating health problems of hazardous waste site communities. According to John Eure from the health department, the primary activities of the department have been associated with providing information and exposure assessments for sites in cooperation with the State Department of Natural Resources. The results of the exposure assessments were not available for review.

KANSAS - The Kansas State Health Department has evaluated over 200 sites in the state using the criteria described in the CDC report "A System for Prevention, Assessment, and Health Effects from Hazardous Sites" (see Table 4 and Reference 38). According to Karen Tappan from the health department, no studies of hazardous waste site communities have begun as a result of this evaluation.

KENTUCKY - The Kentucky State Health Department, according to Walt Lindley, has conducted a 10 year review of vital statistics records for an area surrounding a river contaminated with PCB. Levels of PCB in fish and livestock were also studied. Results of the PCB analysis indicated that levels were increased in fish, but not in livestock, and restrictions on sport and commercial fishing were implemented. Results of the review of vital statistics records were not available for review.

LOUISIANA - Jacquelyn Clarkson from the Louisiana State Health Department indicated that the department uses a team of contracted personnel

to perform exposure evaluations for abandoned and inactive waste sites. Studies of cancer clusters and mortality have also been performed. In addition, the state health department has contracted with researchers from the University of Texas for a health study of the Calasieu Parish Community. The community had reported frequent occurrences of foul odors emanating from two hazardous waste disposal sites in the area; reports of contaminated drinking water and health problems in the community were also received. The study included procedures for evaluating reporting bias and was published in 1985 (63). The authors utilized a self-administered questionnaire that was supplemented with a face-to-face interview. Questions regarding a variety of health outcomes were administered to 671 persons from the Willow Springs Waste site, the Carlyss Waste site or The Le Bleu Area community. In addition, two approaches for estimating reporting bias were included for all participants over 13 years of age. The first approach consisted of an opinion question regarding the effects of waste disposal sites on the environment. The second approach utilized a hypochondriasis index to measure "general attitudes about disease and the reactions of those in his environment to him." The results of the study indicated that an increased number of symptoms were reported for eye, respiratory, upper GI and lower GI symptoms in the Willow Springs waste site community and for respiratory symptoms for the Carlyss Waste site community. High hypochondriasis scores were associated with higher reports of symptoms for residents of all 3 communities. A positive opinion regarding environmental effects of waste sites, however, was associated with higher reports of symptoms for those residents near the waste sites only. The authors concluded that the results of the study indicated that the increased reporting of symptoms in the hazardous waste site communities was probably due to reporting bias. Methods for estimating the effects of reporting bias, according to the authors, should be studied further and included in studies of self-reported health effects of hazardous waste sites.

MICHIGAN - The Toxic Substance Control Commission was established in Michigan in 1978 to "investigate all reports, problems and irregularities which involve or could involve a toxic substance." After receiving several thousand completed questionnaires developed by a group concerned about hazardous waste in their community, the Commission authorized and funded a project to develop a Citizen's Guide for Community Health Studies (64). The guide, developed to provide citizens with an "organizational framework for

launching fact-finding efforts and for using the information generated," includes a detailed description of procedures for performing a community health survey, as well as methods for analyzing and reporting the results of the survey to health officials. According to Dr. James Bedford from the Commission, requests for the guide have been received from several parts of the country and a group in Chicago, Illinois are planning to field test the guide in the near future.

The Michigan State Health Department, according to the review by Grisham (29), proposed an epidemiology study for residents of Montague, Michigan. No information regarding the methods or results of this study, however, were provided.

MINNESOTA - The Minnesota State Department of Health published a report in 1973 of persons exposed to arsenic in drinking water in the town of Pekham (30). The number and severity of symptoms for 13 residents was related to the amount of water consumed. Symptoms included vomiting, diarrhea, nausea, severe abdominal pain and neuropathy. The contaminated well was disconnected and 3 exposed persons were treated for their symptoms. The remaining exposed persons did not need treatment.

The health department, according to Al Williams, has recently contracted for a feasibility study of the Reilly Tar and the New Brighton-Arden Hills sites. The results of these studies indicated that further investigation is not feasible based on the lack of exposure information. Follow-up studies of mortality and cancer rates, however, are planned.

NEW JERSEY - The New Jersey Health Department has participated in several community health surveys (66-69), a study of leukemia and Hodgkins disease in children (70-71), an exposure assessment (72-73), and a study of olfactory functioning in residents near a sewage plant (74).

The community health surveys were conducted at the Price Landfill, the GEMS Landfill and the Krysowaty Farm Waste Site. The survey of residents near the Price Landfill included 56 households along with 53 control households. The survey was conducted over concern for the health of residents exposed to volatile organics from their private wells. A face-to-face questionnaire regarding a variety of symptoms was administered to all members of households in the Price and control areas. Symptoms of rash, skin irritation, joint pain, nausea, abdominal pain, eye irritation, tiredness and muscle pain were reported more frequently in women living near the Price Landfill, while men

reported only symptoms of muscle pain more often. The authors concluded that, although several symptoms were reported more frequently, no long term adverse health effects should develop as a result of formerly drinking contaminated water. A follow-up study to assess if the "expected remission of symptoms" occurs is now under consideration.

The Survey of Health Complaints near GEMS landfill (68) was initiated following complaints about an increased prevalence of nosebleeds in the community near the landfill. The Health Department conducted a house-to-house survey of 80 households in the GEMS area and a control area. The results of the survey indicated that GEMS area residents reported an increased prevalence of respiratory symptoms, nosebleeds, headaches, nausea and bleeding gums (see Table 9). According to the authors, the etiology for the health complaints of the GEMS residents most likely include continued exposure to odors and low levels of volatile organic chemicals. The authors concluded that no excess risk of chronic health effects existed for the GEMS residents and recommended that individuals with nosebleeds be examined to help indicate the cause of this condition. Results of this follow-up study are not available to date.

The health survey of residents near the Krysovaty Farm waste site (69) was conducted in response to complaints of health problems from the community and the presence of heavy metals and organic compounds in residential well water. A questionnaire was administered to all family members of 12 households in the waste site area and 15 households in a control area. The residents living near the Krysovaty Farm site reported more symptoms than the control residents, although only tiredness for women near the waste site was statistically increased. The authors concluded that the levels of exposure to the residents were very low and were not likely to cause the reported health complaints, although the small sample size would have made it difficult to detect even moderate increases in symptoms.

A rather unique approach for studying olfactory functioning was included in a study of residents near and workers in a sewage plant in New Jersey (74).

Residents had complained of odors and burning eyes and throats and low levels of volatile organics were found in the air at and near the plant. The test of olfactory function was a multiple choice task of odor identification. Odorants included 7 that stimulated the olfactory nerve and 3 that stimulated the trigeminal nerve and the olfactory nerve. Test subjects were asked to close their eyes, sniff, and identify each odorant by referring to a list of

items interspersed with distractors. Results of the olfactory testing and a clinical exam indicated a significant relationship between olfactory loss and clinical evidence of nasal disease. Clinical evaluations indicated that 34% of residents, 29% of plant workers and 17% of non-residents had nasal abnormalities. The results of the olfactory testing indicated that 29% of the workers, 26% of the residents and 11% of non-residents had a loss of olfactory functioning. The differences between the groups were not statistically significant. The authors indicated that the olfactory tests were well-received and easy to use in the field. While the results of the tests were not significant for this study, the authors indicated that "as more is learned about the health significance of olfactory deficits in worker and community populations, such an inexpensive, relatively quick, objective evaluation of olfactory complaints would appear to be a useful addition to any field test battery where inflammatory response can be expected."

NEW YORK - Dr. Alice Stark from the New York State Health Department provided a guest editorial regarding community health surveys in 1985 (76). The health department has conducted studies at the Love Canal, Brookfield and Hyde Park sites (77-82), has designed a computerized method for linking health registries with population data and point sources of pollution (83) and has developed a registry of persons exposed to asbestos in drinking water (84).

Studies of Love Canal residents included investigations of cancer and low birthweight rates and cytogenetic analyses. Love canal residents were exposed to chemicals leaking from a disposal site; homes nearest to the site were permanently evacuated in 1978 due to this exposure. Cancer rates and rates of chromosomal aberrations and sister chromatid exchange were not significantly different from control levels, only rates of low birthweight were increased. The significant excess in low birthweight was found in the area closest to the disposal site from 1940 through 1953, during the period of chemical dumping only. Results of these studies have been reported in the published literature.

The Brookfield Health Survey was initiated after numerous complaints from the neighboring community of foul odors and increased health problems. The health survey was "designed to determine if people living close to the landfill had more health complaints and reported medical visits than people living farther from the landfill." In addition, the health survey "was designed to validate the findings of the first phase of the investigation and

determine the medical diagnoses made by the physicians who treated these people." The survey included a telephone interview of 454 Brookfield households and 101 control households. Questions referred to a time period of 6 months prior to the study. Results of the survey are shown in Table 10. Residents of the Brookfield area reported more frequent complaints for 11 of 21 health outcomes. Brookfield residents felt their health was poorer than control residents and more landfill residents felt that their family's health had worsened since moving to the area. Results of the physician questionnaire validated the findings that the percentage of residents who visited physicians was higher in the Brookfield area; these residents had a greater number of diagnoses and illness per 100 persons surveyed. The authors of the survey concluded that "the excess illnesses seen in the study population are compatible with an intermittent exposure to strong odorants and irritants emanating from the landfill." The authors also concluded that "the pattern of illness seen in this investigation suggests an acute noxious exposure rather than a toxic one." Finally, the authors concluded that "it is fair to expect that a return of increased odors in this community will be accompanied by a return of the same types of illnesses documented in this report." The authors recommended that long term air sampling in the landfill area for air contaminants should be continued and that efforts to minimize community exposure to odors should be made.

The above review of health studies of hazardous waste site communities include only those studies performed in the states surveyed. Several additional health studies have been conducted in states that were not surveyed. These studies were conducted in Indiana (26,27,87), Massachusetts (26-29,88), Maine (28,29), Pennsylvania (92,93), Tennessee (26-29,94,95), Texas (26,96,97), Virginia (98), Washington (85,86), West Virginia (99), Wisconsin (26,100), and are summarized in Table 2.

In general, the health studies reviewed above were not initiated as part of the RIFS process (see page 14 for details of RIFS). In addition, the results of the health studies have not altered the course of action of the hazardous waste site remediation. Most of the studies have concluded that the increased reported symptoms would subside when the problems at the waste site were mitigated. According to these studies, site mitigation would also remedy the problems associated with poor perceived health in the community. No direct investigations to substantiate these conclusions, however, have been performed to date.

C. A Citizen's Group Approach

The Citizen's Clearinghouse for Hazardous Wastes has published 2 reports concerning community health studies (101,102). The reports describe the necessary requirements for conducting a successful health study and provide examples of questionnaires for adults and children. The reports also detail several of the problems that have occurred during previous health studies, particularly those performed by CDC, and provide recommendations for minimizing these problems. One recommendation that may be appropriate in certain situations, according to the authors, is consideration of a community health profile instead of a health study. The authors indicate that health profiles are similar to health studies in the way they are conducted but are very different in their intent and interpretation of results. The major purpose of a health profile is to describe the health status of residents rather than assessing whether or not there is a health problem. The results of the health profile, according to the authors, could be analyzed in the same manner as the health study "but without the political risk." If the health profile does not indicate unusual patterns of health problems, continued investigation for possible long-term illnesses can be performed. If unusual patterns are indicated, further study of these problems would be warranted. The primary recommendation of both reports is that the community should be organized, know what they want and maintain control over what happens to address their concerns.

IV. Recommendations for Midway Health Evaluation and Education Program

A. Summary Remarks

The results of the review of federal and state programs indicate that there are two basic approaches being used to address the concerns of hazardous waste site communities across the country. One approach, currently being used in federal programs (EPA, ATSDR), typically does not include studies of health problems of the hazardous waste site community. The other approach, currently being used in several state and local programs, includes methods to provide

quantitative information regarding the health problems in the community. The methods currently being used include reviewing state registry and vital statistics records and to a much lesser degree surveying the community regarding more common health problems and symptoms.

The federal programs typically do not include health studies due to their need to prioritize investigations of toxic exposures and illness (see page 17). Several state and local programs, however, have included health studies of hazardous waste site communities as part of a broader public health program. In general, these local programs are developed in response to community concerns and demands regarding the nature and extent of community exposures and health problems.

The recommendations that are listed below were developed as a result of an assessment of the various options that are available to provide information regarding the health of the Midway Landfill community. The purpose of the recommendations is to develop a Health Evaluation and Education Program that will provide:

- (i) a public forum for an ongoing discussion of health related issues in the community as well as general issues related to environmental risk;
- (ii) greater public health representation in the decision processes related to environmental monitoring of the site;
- (iii) a comprehensive review of available environmental monitoring data from a public health perspective,
- (iv) a greater role for the State Department of Social and Health Services (SDSHS) in evaluating the environmental monitoring program and establishing a health program for the community, and
- (v) a process for the review of procedures that if implemented, will provide quantitative, reliable data regarding the public health problems in the community to better respond to the needs of the feasibility study and the concerns of the community.

B. Recommendations and Some Tasks for Health Evaluation
and Education Program

RECOMMENDATION 1. Response to Report: Community and Agency Comments

Prior to implementing the recommendations regarding the Health Evaluation and Education Program, written comments regarding this report should be solicited and incorporated into an appendix for general review. The author has agreed to respond to written comments, if necessary, by amending the report or providing additional information. Written comments should be solicited from representatives of the:

- (i) Citizen's Advisory Committee
- (ii) Seattle-King County Department of Public Health
- (iii) Washington State Department of Social and Health Services
- (iv) Washington State Department of Ecology
- (v) Environmental Protection Agency
- (vi) Agency for Toxic Substances and Disease Registry
- (vii) University of Washington's Ad Hoc Committee on Midway
Landfill Hazards
- (viii) Midway Action Group

The comments of the citizen's advisory committee should represent the views of the committee as well as a summary of the views of the community. The views of the community should be solicited via a public meeting headed by the author of this report and the citizen's advisory committee. Individual citizens should also be encouraged to provide written comments if they desire to do so.

RECOMMENDATION 2. Evaluation of Environmental Data

The University of Washington's Ad Hoc Committee report entitled "Evaluation of Potential Health Effects Associated with Off-Site Gas Extraction Systems at the Midway Landfill" is, thus far, the only document that provides a summary and evaluation of the environmental monitoring data from a public health perspective. This document was developed from very

limited data pertaining only to exposure to gaseous emissions from extraction wells.

The Department of Ecology is currently in the process of creating a data base management system for all of the environmental monitoring data that have been collected since the Superfund investigation of the Midway Landfill began. This data base should be supplemented with any environmental monitoring data that was collected prior to this investigation, especially during the period that the landfill was in operation. The entire data base, then, should be reviewed in a manner similar to the University's Ad Hoc Committee report, although discussion of noncarcinogenic effects (reproductive, neurotoxic) including issues related to the reporting of an exacerbation of numerous common symptoms should be included.

RECOMMENDATION 3. Remedial Investigation/Feasibility Study (RIFS) Evaluation

The current RIFS plan was developed primarily through negotiations between the Department of Ecology and the City of Seattle. While the Environmental Protection Agency must review and approve the RIFS plan, no such review is required by health experts or any health agency. A review of the RIFS plan to determine whether the current site investigation will provide adequate information for a comprehensive evaluation of the health risks to the surrounding community is recommended. This review should be part of the Environmental Data Evaluation Report (see recommendation 2), since previous environmental monitoring data will influence the requirements of the current RIFS. The development of this report should be supported by the Department of Ecology.

Finally, a representative from DSHS should be included in future negotiations regarding the site investigation and should report on the progress of the site investigation to the Health Evaluation and Education Work Group.

RECOMMENDATION 4. Formation of a Health Evaluation and Education Work Group

While numerous committees have been established to discuss issues related to the remedial investigation, a format has yet to be established that would provide an adequate ongoing discussion of the health concerns of the

community. It is recommended, therefore, that a community Health Evaluation and Education Work Group be established to provide a continuous format for the discussion of health related issues. This work group should include representatives of the Midway Landfill community (including health providers who live in or serve the community) and the City of Seattle, the Seattle-King County Health Department, the Department of Ecology, DSHS and local EPA and CDC representatives. The meetings of the Work Group should be co-chaired by a representative of the Midway community and a representative from DSHS and should be open to all interested Midway Landfill residents. The work group should:

- (i) discuss the current EPA and ATSDR criteria for evaluating the health effects of hazardous waste sites;
- (ii) discuss the current ATSDR criteria for performing health studies of hazardous waste site communities (see page 5);
- (iii) discuss the ongoing negotiations, procedures and results regarding the site investigation;
- (iv) prioritize the health evaluation tasks listed below or proposed by others;
- (v) evaluate the appropriate administrative procedures for implementing health evaluation tasks (e.g., internal agency health experts vs external consultants or contractors);
- (vi) evaluate proposals for implementing health evaluation tasks;
- (vii) recommend health evaluation scientists to implement the tasks;
- (viii) provide ongoing oversight of the implementation of health evaluation tasks;
- (ix) evaluate the results of health evaluation tasks; and
- (x) disseminate information regarding the objectives, procedures and results of health evaluation tasks to the Midway community.

SOME HEALTH EVALUATION TASKS FOR CONSIDERATION BY THE HEALTH EVALUATION AND EDUCATION WORK GROUP

The following health evaluation tasks are provided for discussion by the work group. These tasks are included because they represent the most common procedures that have been used to provide quantitative information concerning

the health status of the community during the site investigation. Other tasks should be considered by the Work Group, as well as factors that influence the likelihood that these tasks can be implemented (e.g., funding source, availability of health experts), a task beyond the scope of this report.

TASK 1. Cancer Study: Census Blocks

The Fred Hutchinson Cancer Research Center's Cancer Surveillance System (CSS) has been in place since 1974. With cooperation from the 58 area hospitals, as well as private pathology laboratories, the CSS identifies over 99% of incident cancers occurring in the 13 counties of western Washington. This information is coded to the census tract (CT) level. Previous studies have reported cancer rates for census tracts adjacent to waste sites, while others have coded cancers to the census block level. Census blocks (CB's) are subdivisions of census tracts defined in such a way as to try to keep the number of people in each block approximately the same: in urban areas, they are basically one city block, in less dense areas they are correspondingly bigger. In the absence of any detailed environmental information, all CB's making up the "affected area" around the landfill (based on the best available data) would become the exposed group, and all other CB's within the adjacent census tracts or King County as a whole could make up a comparison group. As additional environmental data become available, each CB could be assigned a simple (2 or 3 level) code for each "exposure" (e.g. CB-1 might be high-exposed for migrating methane, but low-exposed for a different contaminant). Cancer rates (or any available medical event data having been coded to the appropriate CB) could then be reanalyzed for associations with each exposure type. This study could be done in a relatively short period of time (approximately 4 months) and would provide specific information regarding cancer rates in the Midway community. Due to the small size of the population in the study, however, increases in individual cancers would be very difficult to detected. For example, if one defines the maximum population "at risk" from the landfill to be all those in CT 291 (N = 4917, 1985 estimates) and half those in CT 290 (N = 8770), approximately 9000 persons would be defined. Assuming a largely white population, and age and sex distributions similar to the nation as a whole, there would be approximately 29 cancers expected in this population per year (based on 1973-77 SEER cancer rates). By coding all

cancers identified by the CSS in the two CT's to the census block level, the incidence rates for this population (as well as any subpopulation that could be defined based on more detailed exposure assessments) could be calculated and compared to rates from King County as a whole. Figure 1 describes the minimum detectable relative risks (MDR) that could be found from such a study that coded cancer data from as far back as 1978 (when the boundaries of CT's were changed). Assumptions include a two-tailed alpha level of 0.05 and a statistical power of 90%. If CB's encompassing 2000 people were defined as most highly exposed to important contaminants, the MDR for all cancers would be approximately 1.5. However, since it would be extremely unlikely that any contaminant would increase the rate of all cancers, it is more informative to examine the MDR's associated with individual types of cancer such as respiratory (MDR = 2.5) or leukemia (MDR = 5.8). Increases of this magnitude are rarely observed in studies of environmental exposures. In addition, this study will not provide information regarding the risk of current residents developing cancer in the future. These limitations should be discussed by the work group prior to implementing this study so that all participants are aware of how to interpret the results.

TASK 2. Birth Certificate Study: Census Blocks

Birth certificate data are also available with pre-coded census tract information. The 1984 and 1985 data have check-boxes for congenital malformations which seem to improve the reporting of them (at least those identified in the first several days of birth). These data could be analyzed in much the same way as the cancer data: coded down to the census block level, assigned exposures based on best available information, and compared to the experience of King County as a whole. In addition, other adverse outcomes of interest, such as low birthweight, low Apgar scores, and previous spontaneous abortions could also be examined using birth certificate data. Again, this study could be performed in a relatively short period of time (approximately 6 months) and would provide specific information regarding congenital malformations and other adverse outcomes in the Midway community. Limitations in the ability to detect a difference in an "exposed" group, however, would be even greater than those of the cancer study. For example, there would only be approximately 80 births a year expected in the population

of 9000 from the two CT's of interest, yielding much less statistical power to detect moderate increases in risk. In addition, it is also unlikely that any particular contaminant would be associated with all types of malformations; specific malformation types such as cardiovascular defects would need to be examined, with consequent large reductions in power. These limitations should be discussed in detail by the work group.

TASK 3. Community Health Survey: Current Population/Census Blocks

While the results of the cancer registry and birth certificate studies provide important information regarding these health outcomes, the health problems that are usually reported by hazardous waste site communities are typically examined via a health survey. Previous surveys have utilized face-to-face or telephone interviews of a family member to collect health information regarding the entire family. Other studies have relied on self-administered surveys of all family members. The majority of these surveys have attempted to compare all families within the potentially affected area with families in a separate control area.

The prevalence of various symptoms reported from previous landfill surveys has varied widely depending on the wording of the questionnaire, the time period it encompassed and other factors. Estimates of minimum detectable relative risks from health survey studies as a function of both the number of persons considered to be exposed and the prevalence of the particular symptom or condition under study are given in Figure 2. For example, if 500 exposed people are interviewed (and an equal number of unexposed), the study would be able to detect an approximate two-fold relative risk for a condition reported by 5% of the controls (again assuming 90% power and a two-sided alpha level of 0.05). This two-fold relative risk would not be substantially reduced if additional persons were interviewed (see Figure 2). More rare conditions, however, would be associated with a much higher relative risk (over 4-fold) if 500 exposed and control persons were interviewed. The relative risk of these conditions, although still high, would be reduced if additional persons were interviewed. If the study area for the health survey were defined according to the description above (eg., census tracts 291 and one-half of 290), the primary factors determining the number of subjects to interview within this area would include the estimated number of exposed persons and the importance

of detecting increases in rare conditions. The interest of the community in obtaining a complete census of residents in the study area to provide basic information for further studies or registries should also be considered in this decision.

Due to the numerous problems inherent in survey research the results of health studies are generally not considered reliable indicators of the type and extent of health problems in the community. Therefore, a health survey, if implemented, should be considered only the first phase of an investigation regarding the prevalence of common diseases and illnesses in the community. Depending on the outcome of the survey (i.e., which diseases are reportedly increased), follow-up studies to validate certain conditions by review of medical records or physician examinations or possibly a case control study should be considered. Finally, authors of several previous health surveys have indicated that the increased prevalence of symptoms that are reported by hazardous waste site communities should return to normal once the problems associated with the site are mitigated or once the families move from the area. Thus far, these comments have been based on anecdotal information from families who have chosen to leave waste site areas. Little or no quantitative data are available from communities following waste site cleanup. Future designs should include efforts to quantify changes in perceived health for families that have chosen to move from the area, as well as from hazardous waste site communities following the mitigation of environmental problems in their area. Procedures to minimize and estimate the influence of recall bias should also be considered important components of any health survey procedure.

TASK: 4. Midway/Parkside School Study: Current Population

Many of the health problems reported by Midway residents have been observed in children who live in the area. Several residents have requested that children from the Parkside and Midway schools be studied, since children from inside and outside the Midway community are now attending these schools. Particular concern for young children (grades 1-3) that are now being bused from outside the Midway area to Parkside school has been expressed. Procedures for studying the health problems of children from the Parkside and Midway school would not involve extensive resources in addition to the health survey (Task 3). Families with children attending the Parkside and Midway schools, who do not live in the Midway area, could easily be identified from school records and included in the health survey.

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TABLE 1

SUMMARY DATA ON SOLID WASTE FACILITIES

Percent of uncontrolled sites that are solid waste facilities:		
Of 1,389 sites with actual or presumed problems of releases of hazardous substances.....	18%	
Of 550 sites on National Priority List.....	20%	
Two most prevalent effects at problem solid waste sites:		
Leachate migration, groundwater pollution:		
at 89% of sites		
Drinking water contamination: at 49% of sites		
Mean size of problem solid wastes sites.....	67.4	acres
Median hazard ranking score: ^a		
Solid waste sites on the NPL.....	40.8	
All NPL sites.....	42.2	
Estimates for national number of solid waste sites:		
Operating sanitary, municipal landfills.....	14,000	
Closed sanitary, municipal landfills.....	42,000	
Operating industrial landfills.....	75,000	
Closed industrial landfills.....	150,000	
Operating surface impoundments.....	170,000	
Closed surface impoundments.....	170,000	
Total.....	621,000	
Estimate of need for future cleanup:		
Low: 5% landfills, 1% impoundments likely		
to release toxic substances.....	17,400	
High: 10% landfills, 2% impoundments likely		
to release toxic substances.....	34,800	
Conservative figure used for cleanup by Superfund.....	5,000	

^a28.5 required for placement on National Priorities List; current highest site score is 75.6.

SOURCE: Reproduced from Office of Technology Assessment, Superfund Strategy, April, 1985 (3).

TABLE 2

SUMMARY OF HEALTH STUDIES OF HAZARDOUS WASTE SITE COMMUNITIES

<u>SITE</u>	<u>NPL#</u>	<u>EXPOSURES</u>	<u>RESULTS</u>	<u>REFERENCES</u>
Triana/Tennessee River, AL	31	Serum DDT levels in exposed residents	Altered lipid & liver metabolism	(26,27,40)
Tucson International Airport Area, AZ	70	Exposed & control areas TCE in well water	↑ School absenteeism, no ↑ defects & mortality	(43-46)
Mountain View Mobile Home Estates, AZ	94	Asbestos in air, soil & dust of exposed residents	No current asbestos related diseases	(41,42)
Vertac Inc., AR	18	Urine levels of 11 chemicals related to herbicide exposure in exposed & control children	No health problems studied	(47)
56 Stringfellow, CA	32	Exposed & control areas Multiple contaminants	↑ Earache, nausea, headache, skin rash, sinus blockage, dizziness	(50,51)
Operating Industries, CA	71	Exposed & control areas Multiple contaminants	↑ Headache, nausea, eye & skin irritation, tiredness; no ↑ death, cancer, pregnancy problems	(52)
Purity Oil, CA	280	NR	NR	(54)
McColl, CA	335	Exposed odor areas & control area, Multiple petroleum contaminants	↑ Headache, nervousness & other "bothersome" symptoms	(27-29,48,49)
Fairchild Camera & Instrument Corp., CA	P	Exposed & control areas TCE & DCE in well water	↑ Spontaneous abortions & birth defects	(28,55-57)
Del Amo, CA	NL	Exposed & control areas Multiple contaminants	NR	(53)
BKK Landfill, CA	NL	Exposed & control areas Multiple contaminants	No ↑ skin rashes & cancer	(58-60)

TABLE 2 (continued)

SUMMARY OF HEALTH STUDIES OF HAZARDOUS WASTE SITE COMMUNITIES

<u>SITE</u>	<u>NPL#</u>	<u>EXPOSURES</u>	<u>RESULTS</u>	<u>REFERENCES</u>
Bunker Hill Mining & Metallurg Complex, ID	106	Blood lead levels in exposed children	↑ Lead toxicity (BL > 25 g/dl & EP > 35 g/dl), anemia; ↓ nerve conduction velocity	(26,61,62)
Neal's Landfill (Bloomington), IN	290	Serum PCB levels in exposed & control residents	Altered lipid metabolism	(26,27,87)
Calcasieu Parish, LA	NL	Exposed & control areas Multiple contaminants	↑ Eye, respiratory & other reported symptoms associated with "reporting bias"	(63)
New Bedford Site, MA	80	Serum PCB levels in exposed residents	No health problems studied	(27-29)
57 Silresim Chemical Corp., MA	293	Exposed & control areas Multiple contaminants	↑ Respiratory symptoms, headache, fatigue, heart problems	(28,29)
Wells G&H (Woburn), MA	294	Water usage in residents with Pb, As, TCE in well water	↑ Leukemia, perinatal mortality, birth defects, childhood sickness	(26-29,88)
McKin CO., ME	33	Residents exposed to TCE in well water	NR	(28,29)
E.I. Du Pont De Nemours & CO., INC. (Montague Plant), MI	P	Residents exposed to multiple contaminants in well water & fish	NR	(28,29)
"PCB Site in Mich.", MI	NL	Serum PCB levels in exposed & control residents	Altered immune function, no skin, liver problems	(26,27,65)
St. Regis Paper CO., MN	133	NR	NR	(28)
Perham Arsenic Site, MN	411	Hair arsenic levels in exposed residents	Neuropathy & intestinal disorders	(28,30,66)

TABLE 2 (continued)

SUMMARY OF HEALTH STUDIES OF HAZARDOUS WASTE SITE COMMUNITIES

<u>SITE</u>	<u>NPL#</u>	<u>EXPOSURES</u>	<u>RESULTS</u>	<u>REFERENCES</u>
Times Beach/Shenandoah Stables, MO	366 663	Exposed & control areas 2,3,7,8- TCDD sprayed on soil	Altered liver & immune function tests	(89-91)
Lipari Landfill, NJ	1	Exposed & control areas Multiple contaminants	NR	(75)
Price Landfill, NJ	6	Exposed & control areas Multiple contaminants in well water	↑ Eye irritation, rash, tiredness, muscle pain, nausea, pregnancy problems	(28,29,66)
"GEMS" Landfill, NJ	12	Exposed & control areas Multiple contaminants	↑ Respiratory symptoms, nosebleeds, headaches, nausea, no ↑ reproductive, pulmonary effects	(27-29,67,68)
58 Krysowaty Farm, NJ	103	Exposed & control areas Multiple contaminants in well water	↑ Tiredness for women, no ↑ numerous other reported symptoms	(28,29,69)
Universal Oil Prod. (Chem. Div.), NJ	108	Exposed & control children Benzene, TCE	↑ Leukemia & Hodgkins disease	(28,29,70,71)
Reich's Farms, NJ	122	Residents exposed to multiple contaminants in well water	No association between illness & well water use	(28,29)
Jackson Township Landfill, NJ	407	Residents exposed to multiple contaminants in well water	↑ Skin, kidney problems, hospitalization; no ↑ reproductive problems	(28,29)
Pomona Oaks Residential Wells, NJ	600	Residents exposed to Benzene & Volatile Organics	↑ Cancer risk through inhalation of contaminated shower water	(29,72,73)
Sussex County Municipal Utility Authority, NJ	NL	Exposed & control areas multiple petroleum contaminants	↑ Headaches, sore throats, eye irritation, altered immune system, no ↑ olfactory loss	(74)

TABLE 2 (continued)

SUMMARY OF HEALTH STUDIES OF HAZARDOUS WASTE SITE COMMUNITIES

<u>SITE</u>	<u>NPL#</u>	<u>EXPOSURES</u>	<u>RESULTS</u>	<u>REFERENCES</u>
GE Moreau "Caputo", NY	52	NR	NR	(28)
Love Canal, NY	139	Exposed & control areas multiple contaminants	↑ Spontaneous abortions, LBW infants; no ↑ leukemia, cancer, chromosome aberrations	(26-29, 77-79)
Hooker (Hyde Park), NY	510	Blood pesticide levels in exposed residents	↑ Gastrointestinal symptoms, cough, benign tumors	(27-29, 82)
Brookfield Avenue Landfill, NY	NL	Exposed & control areas Multiple contaminants	↑ Cough, headache, nausea, URI, sinusitis, medication; no ↑ doctor visits, hospitalization	(28, 29, 81)
59 Woodstock, NY	NL	Residents exposed to asbestos in drinking water	NR	(84)
Drake Chemical, PA	394	Exposed & control areas Multiple contaminants	↑ Cancer, skin problems, sleepiness; no ↑ birth defects, numerous reported symptoms	(28, 29, 92, 93)
Wade (ABM), PA	452	Residents exposed to Multiple contaminants	No ↑ neurologic, hematologic, liver abnormalities	(26-29)
Old City of York Landfill, PA	540	NR	NR	(28)
Stanley Kessler, PA	544	Urine levels of TCE metabolites in exposed residents	No acute illness reported	(28, 29)
North Hollywood Dump, TN	95	Exposed & control areas Multiple contaminants	↑ Heart murmur, cough, urinary infection, mental illness, arthritis, digitalis medication; no ↑ numerous other symptoms	(27, 94)

TABLE 2 (continued)

SUMMARY OF HEALTH STUDIES OF HAZARDOUS WASTE SITE COMMUNITIES

<u>SITE</u>	<u>NPL#</u>	<u>EXPOSURES</u>	<u>RESULTS</u>	<u>REFERENCES</u>
Velsicol Chem. (Hardeman County), TN	200	Exposed & control residents Multiple contaminants in well water	↑ Altered liver function; No ↑ altered renal function, skin or eye problems	(26-29,95)
"Lead Smelter in Texas", TX	NL	Blood lead levels in Exposed & control children	↓ Motor response, intelligence scores	(26,96,97)
"Arsenic Site", VA	NL	Urine arsenic levels in exposed residents	Gastroenteritis, Encephalopathy, Nephropathy, Hepatitis	(98)
Commencement Bay, Near Shore/Tide Flats, WA	329	Urine arsenic levels in exposed residents	No ↑ absenteeism, hearing loss, birth defects, low birthweight infants	(85,86)
3 Kanawha County, WV	NL	Exposed & control areas vinyl chloride monomer	↑ Central nervous system malformations in newborns	(99)
"Phenol Spill", WI	NL	Exposed & control areas Phenols in well water	↑ diarrhea, mouth sores, burning mouth; no ↑ symptoms after 6 months	(26,100)

TABLE 3

QUESTIONS IN EXPOSURE ASSESSMENT

I. Chemical Identification

- A. What chemicals are known or suspected to have been disposed at the site?
- B. What quantities of each chemical were disposed?
- C. How were they disposed (bulk dumping, drums, bulk storage)?
- D. Which chemicals are now in the environment (air, land, surface water, ground water)?
- E. What are the ambient levels of these chemicals in the air, ground water, surface water, and soil?
- F. What conditions or events could affect contamination levels on- and off-site?
- G. What chemicals can be used as indicators of the overall risk at the site?

II. Surrounding Population

- A. Describe the population surrounding the site:
 - 1. How many people are potentially exposed?
 - 2. Who are they (especially high-risk groups, e.g., children, the elderly, or the ill)?
 - 3. Where is the population located relative to the site?
 - 4. Is the area mainly for residence or business?
 - 5. What type of access is there to the site?
 - 6. What normal activities might be affected by contamination (e.g., farming by contaminated soil)?
- B. What, if any, health-related complaints have been received? Have these been documented or proven to be related to the site?

III. Potential Exposure Routes

- A. Unavoidable on-site exposure (residences, etc.)
 - 1. How are people exposed?
 - 2. What are the routes of exposure (through inhalation, the skin, or ingestion)?
 - 3. To what chemicals are people exposed?
 - 4. To what levels are they exposed (use monitoring data and modeling if appropriate)?
 - 5. How many people are exposed at these levels (i.e., through each pathway)?
- B. Voluntary on-site exposure
 - 1. How are people exposed?
 - 2. What are the routes of exposure (through inhalation, the skin, or ingestion)?
 - 3. To what chemicals are people exposed?
 - 4. To what levels are they exposed (use monitoring data and modeling if appropriate) and how many people are exposed at these levels (i.e., through each pathway)?
 - 5. Can this exposure be prevented?

TABLE 3 (CONTINUED)

QUESTIONS IN EXPOSURE ASSESSMENT

- C. Off-site exposure (actual and potential)
 - 1. What environmental routes must chemicals take for exposure?
 - 2. How likely are these routes of exposure?
 - 3. When is exposure expected to occur?
 - 4. How are people exposed (through inhalation, the skin, or ingestion)?
 - 5. To what chemicals are people exposed?
 - 6. To what levels are they exposed (use monitoring data and modeling if appropriate)?
 - 7. How many people are exposed at these levels (i.e., through each pathway)?
 - D. Other non-waste-related exposures
 - 1. Is the population, or are segments of the population, exposed to any of these chemicals from other routes, e.g., in the workplace?
 - 2. Are the ambient environmental levels of any of the chemicals known?
 - 3. Are they suspected to be abnormally high for any reason?
- IV. The Effect of Not Taking Action
- A. Technical issues
 - 1. What will happen if no action is taken (e.g., lagoon failure, aquifer contamination, drum failure, air contamination)?
 - 2. What chemicals will be of concern?
 - B. Exposure issues
 - 1. What exposure will result from not taking action?
 - 2. Will exposure increase indefinitely?
 - 3. Will exposure rise and then fall? Over what time?
 - 4. What is the predicted range of eventual contamination and exposure?

Source: Reproduced from Environmental Protection Agency, Guidance on Feasibility Studies under CERCLA, June, 1985 (34)

TABLE 4
CHECKLIST FOR USE IN ASSESSING FEASIBILITY OF HEALTH STUDIES
For each factor on the list, enter a check beneath the applicable criterion
level (0, 1, 2, 3, or unknown)

	<u>Unknown</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>
FEASIBILITY OF CONDUCTING HEALTH EFFECTS STUDIES					
Availability of information on time periods and levels of exposure	no data/ no conclusion	information unlikely to be available through studies of biological levels or through interviews	reasonably reliable information available through interviews with population	feasible to obtain information from study of biological levels (See factors 1a - 1e)	information already available as result of study of biological levels
.....
Knowledge of what health effects to study	no data/ no conclusion	knowledge based only on complaints	possible effects of exposure can be extrapolated from animal data	possible effects of exposure are known, based on limited human data	probable effects of exposure are known based on more complete human data
.....
Specificity of health effect(s) to be studied	no data/ no conclusion	many possible causes of health effect	health effect relatively non-specific	health effect relatively specific	health effect caused <u>only</u> by the substance in question
.....
Availability of enough exposed people to allow statistically valid conclusions from the study (Number required would depend on probable frequency of effect to be studied and on multiple factor etiology.)	no data/ no conclusion	inadequate	marginally inadequate	marginally adequate	number adequate
.....
Availability of resources (e.g., qualified personnel funds, laboratory support)	no data/ no conclusion	none	minimal	adequate	excellent
.....
Likelihood of cooperation from community, local health department, etc.	no data/ no conclusion	none	minimal	adequate	excellent

Source: A System for Prevention, Assessment, and Control of Exposures and Health Effects from Hazardous Sites (38)

TABLE 5

SUMMARY OF HEALTH ACTIVITIES OF STATES INCLUDED IN TELEPHONE SURVEY

<u>STATE</u>	<u>HEALTH ACTIVITIES</u>
ALABAMA	Participated in two health studies (Triana ² and Interstate Lead Co. ³ sites) with CDC.
ARIZONA	Participated in health study at Mountain View Mobile Home Estates with CDC ² , conducted health studies ² and established review committee ² at Tucson International Airport Site.
ARKANSAS	Participated in exposure study at Vertac Inc. site with CDC ² .
CALIFORNIA	Conducted five health studies of hazardous waste site communities (McColl, ² Stringfellow, ² Operating Industries, ³ Del Amo, ² Purity Oil ³), conducted reproductive and cardiac defect studies at Fairchild Site, ² established health committee and contracted independent exposure assessment cancer study at BKK Landfill Site. ²
COLORADO	Cancer Registry information for some sites. ³ Sites not specified.
CONNECTICUT	Conducted exposure evaluation and school attendance study at Laurel Park, Inc. Site. ³
DELAWARE	Conducted exposure assessment (blood liver enzymes) at Delaware City PVC Plant Site. ³

TABLE 5 (CONTINUED)

SUMMARY OF HEALTH ACTIVITIES OF STATES INCLUDED IN TELEPHONE SURVEY

FLORIDA	Conducted review of doctors records, birth defects, and cancer statistics for some sites. ³ Site not specified.
GEORGIA	Conducted study to define individuals at high risk for exposure to DDT and PCB for two sites. ³ Biological indicators of PCB and DDT metabolites studied with CDC. ³
IDAHO	Conducted studies related to Bunker Hill mining site. ²
IOWA	Conduct exposure assessment and review of cancer and birth defects registry at some sites. ³ Sites not specified.
KANSAS	Evaluated 201 sites in state according to CDC health studies document. ³
KENTUCKY	Conducted biological monitoring of fish and livestock for PCB. Review of vital statistics of local community. ³
LOUISIANA	Contacted independent experts to perform exposure evaluations ³ . Citizen group sponsored study at site. ²

TABLE 5 (CONTINUED)

SUMMARY OF HEALTH ACTIVITIES OF STATES INCLUDED IN TELEPHONE SURVEY

MICHIGAN	Establish State Toxic Substance Control Commission to review possible toxic exposures. Sponsored development of Citizen's Guide for Community Health Studies. ² Proposed Epidemiology study for Montague Plant Site. ³
MINNESOTA	Sponsored independent feasibility study for Health Study at two sites (Reilly TAR and New Brighton). ³
NEW JERSEY	Conducted health studies at Kryswaty Farm, GEMS and Price Landfill sites. ² Conducted exposure assessment at Pomona Oaks site. ² Conducted olfactory study at Sussex Municipal Authority. ² Established health committee at Lipari Landfill Site. ²
NEW YORK	Conducted health studies at Love Canal and Brookfield Landfill sites. ² Conducted biological monitoring at Hyde Park site. ² Established procedure for linking health outcome with environmental point source pollution ² and established exposure/outcome registry for Woodstock site. ²

¹ This list does not necessarily reflect all activities of the state

² Reports received by author

³ Reports not received by author

Table 7

Summary of Significant Results From
Stringfellow Health Effects Study

Increased Incidence Rates for diseases among individuals 20
years or older

1. Ear Infection
2. Angina
3. Skin Rash

Increased Prevalence Ratios for symptoms among individuals 20
years or older

1. Pain or Drainage of Ears
2. Nausea or Indigestion
3. Urinating at Night

Increased Prevalence Ratios for symptoms among individuals
under 20 years of age

1. Frequent sinus Blockages
2. Headaches
3. Tiring Easily
4. Dizziness
5. Urinating at Night

Source: The Stringfellow Health Effects Study, An
Epidemiologic Health Survey of Residents of Glen
Avon and Rubidoux, California, February, 1986
(50,51).

Table 6

Symptoms¹ reported by respondents, McColl Site Adult Health Survey, 1982.

Feeling nervous, fidgety or tense ²	Runny nose ²
Headaches ²	Sore throats ²
Trouble sleeping ²	Allergies ²
Feeling too tired to do things ²	Nosebleeds
Dizzy spells ²	Earaches
Feeling nauseated ²	Chest pains ²
Losing your appetite ²	Coughing ²
Stomach pains or aches ²	Wheezing ²
Diarrhea	Hives or other skin problems ²
Sinus congestion ²	Pain from phlebitis
Irritated or sore eyes ²	Bleeding gums
Burning or irritated nose or windpipe ²	Bruising easily
(nasal passage irritation)	Colds

¹ These symptoms were reported in response to direct questions asked in the questionnaire.

² Reported symptom related to odor zones.

Modified from the McColl Site Health Survey, 1983 (48,49)

TABLE 8

Specific Aims of Report Entitled "Methodology for Evaluating Cancer Risk in Small Communities," University of Southern California, 1985.

1. Is the observed occurrence of all cancers or of any etiologically distinct cancer elevated in frequency among the adults or children living near a toxic contamination site?
2. Are the specific excesses or the overall pattern of risks different from what one might expect simply by chance? From what one might expect in similar communities? Which of the observed elevations are most likely to be real? What is the magnitude of the excess burden of disease?
3. Is there an increasing risk over time? Is there consistency in the findings between adjacent areas, between the sexes, or between etiologically related types of neoplasms?
4. Do the cases tend to cluster near to the site of contamination or near to each other in space, time, or both? Are the cases unusually homogeneous in terms of demographic characteristics? Is a local common etiology, a specific mechanism of exposure, a specific alternative etiology, a specific mechanism of exposure, a specific alternative etiology or a local modifying factor suggested?
5. How should the excesses be ranked in terms of their likelihood of representing real associations or in terms of their priority for further investigation or action?
6. How plausible is an etiologic role for exposure to environmental carcinogens?
7. Could a more complete explanation of any excesses be produced by analytic studies?

Source: Modified From Methodology for Evaluating Cancer Risk in Small Communities, 1985 (59)

TABLE 9

Number of Individuals with Symptoms
Reported in the GEMS Vicinity and the Comparison Group¹

Symptom	GEMS Area			Laurel Hills	
	Fox Chase	Other	Total		
	% (n)	% (n)	% (n)	%	(n)
nosebleeds	27 (24)	8 (6)	19 (30)	11	(16)
coughs	28 (24)	26 (19)	27 (43)	24	(36)
dry cough	8 (7)	3 (2)	6 (9)	1	(1)
bruising	9 (8)	8 (6)	9 (14)	10	(15)
allergy	27 (22)	22 (16)	24 (38)	33	(50)
asthma	8 (7)	4 (3)	6 (10)	6	(9)
sore throat	54 (47)	32 (23)	44 (70)	32	(48)
wheezing	17 (15)	7 (5)	13 (20)	12	(18)
tight chest	21 (18)	10 (7)	16 (25)	8	(12)
short of breath	19 (16)	11 (8)	15 (24)	11	(17)
colds	55 (48)	29 (21)	43 (69)	32	(48)
nasal congestion	44 (39)	40 (29)	42 (68)	47	(71)
eye irritation	22 (19)	18 (13)	20 (32)	17	(26)
bleeding gums	11 (10)	10 (7)	11 (17)	5	(7)
skin rash	22 (19)	25 (18)	23 (37)	43	(28)
nervousness	21 (18)	21 (17)	22 (35)	11	(17)
fatigue	18 (15)	15 (12)	17 (27)	13	(19)
diarrhea/ constipation	24 (21)	14 (10)	20 (31)	17	(26)
headache	44 (38)	26 (19)	36 (57)	26	(38)
nausea	12 (10)	14 (10)	13 (20)	26	(7)
dizziness	7 (6)	7 (5)	7 (11)	6	(8)

¹ only positive or negative replies are included in totals on which percentages are based.

SOURCE: Modified from Survey of Health Complaints Near the GEMS Landfill, 1985 (68)

TABLE 10

Resident Health Survey

Reported Health Complaints for Study and Control Areas
Medical Visits

	Study Area (n=1661) %	Control Area (n=323) %	Mantel-Haenszel χ^2 (Age Adjusted)	p
Visited M.D. in last 6 months	45.2	26.3	44.8	< .01
Complaint:				
Chest or Breathing	15.2	4.6	25.2	< .01
cough	7.2	1.2	15.1	< .01
pneumonia	1.3	0.0	2.9	N.S
asthma	2.0	0.3	3.63	N.S
bronchitis	3.6	1.2	2.77	N.S
emphysema	0.2	0.0	0.11	N.S
Eye, Ear, Nose & Throat	24.5	12.4	19.4	< .01
sinusitis	5.0	1.2	8.5	< .01
hay fever, allergies	6.4	2.2	6.86	< .01
recurrent sore throat	9.4	2.5	14.38	< .01
tonsillitis	1.4	0.9	0.05	N.S
Stomach	5.8	3.1	4.31	< .05
Kidney	2.5	1.5	1.06	N.S
Muscle/Bone	4.6	3.4	0.08	N.S
Nerves (Headache)	3.9	0.9	7.08	< .01
Heart	3.5	2.5	3.84	< .05
Blood	1.5	1.5	0.00	N.S
Gyn	1.9	0.6	1.52	N.S
Skin	5.2	3.1	2.69	N.S
Emotional	1.6	0.0	4.15	< .05

Note: N.S. = Not significant at p value $> .05$

SOURCE: Reproduced from Report on the Brookfield Health Survey (81)

Figure 1

Minimum Detectable Relative Risks - Cancer

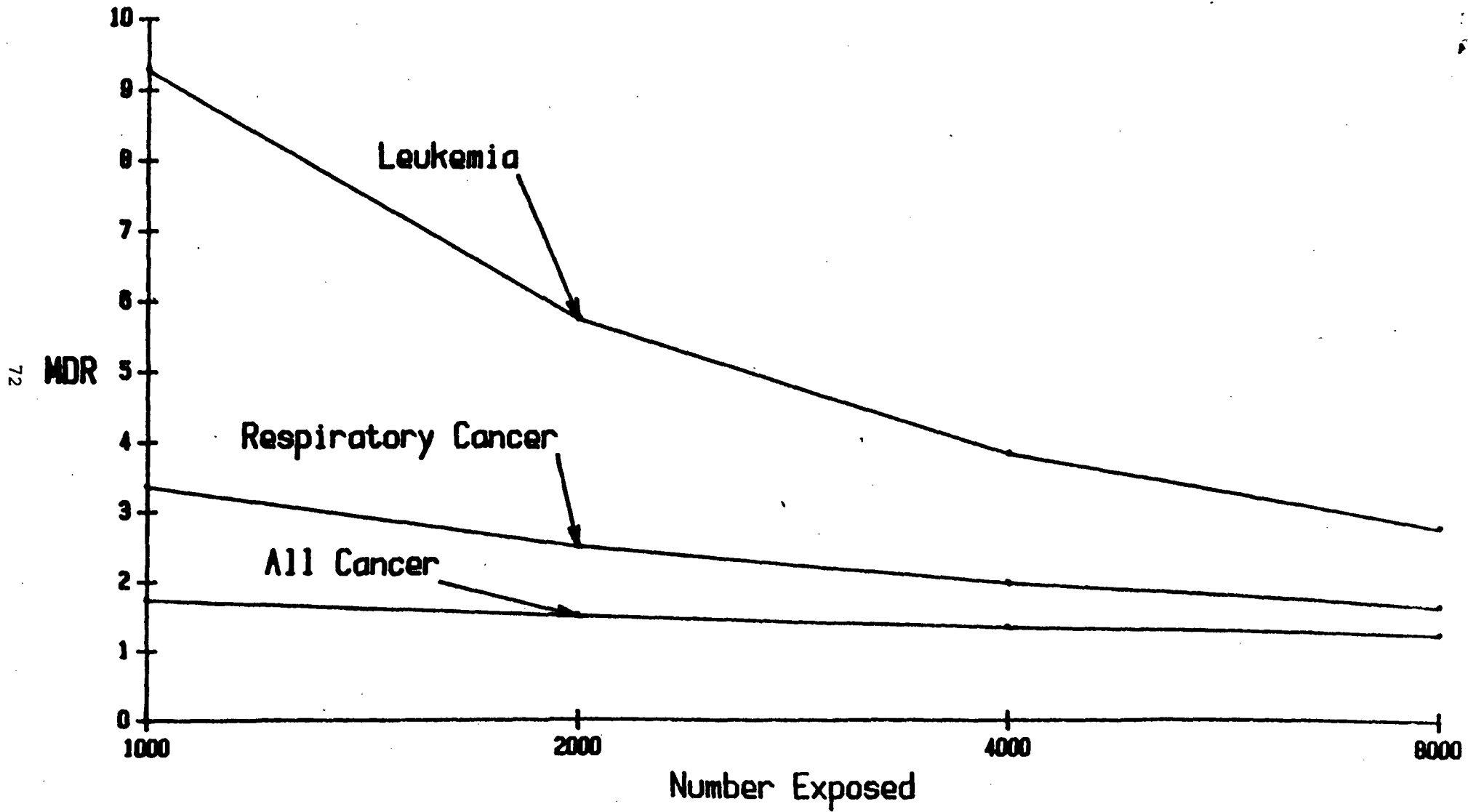


Figure 2

Minimum Detectable Relative Risk - Symptoms

